Environment Canada Environnement Canada
2035114I VOL ISS 3 791200
EXC # 001

<REPORT> CC

OOFF

# HEXACHLOROBENZENE (HCB) IN CANADA

# HEXACHLOROBENZENE (HCB) IN CANADA

Three Reports to the Department of the Environment/Department of National Health and Welfare Environmental Contaminants Committee

*The Environmental Impact Control Directorate has sent a limited number of copies of this document to interested parties. This distribution is not intended to signify publication and, if the report is referenced, the author should cite it as an unpublished report of the Branch indicated below. Any comments concerning its contents should be directed to:*

*Contaminants Control Branch*
*Environmental Impact Control Directorate*
*Environmental Protection Service*
*Environment Canada*
*Ottawa, Ontario*
*K1A 1C8*

## ABSTRACT

Information was developed in 1978 on hexachlorobenzene (HCB) with respect to its influence on human health and the environment in Canada. A further document on sources of HCB to the Canadian environment was compiled in 1979. The reports, collected in this document, served as the background information for a decision in 1979 by the Department of Environment/National Health and Welfare Environmental Contaminants Committee. The decision on HCB was summarized in Priority Chemicals- 1979, and published in the Canada Gazette, December 1, 1979, as follows:

> "Hexachlorobenzene, a waste-product of several industrial chemical processes, is persistent and can bioaccumulated. Review of the national situation indicates that levels in the environment, some of which are decreasing, are not of immediate concern. Regulatory action is, therefore, not presently warranted. Point source and general environmental monitoring are still needed and efforts to further reduce entry of HCB into the environment must continue."

## RÉSUMÉ

En 1978, on a réuni des renseignements sur les effets de l'hexachlorobenzène (HCB) sur la santé et l'environnement au Canada. En 1979, on rédigeait un autre document sur les sources de HCB présent dans l'environnement au Canada. Les rapports, réunis dans le présent document, ont servi en 1979 au Comité des contaminants de l'environnement des ministères de l'Environnement et de la Santé et du Bien-être à rendre une décision, reproduite de façon abrégée dans la liste des produits chimiques d'intérêt prioritaire (1979) et publiée dans la Gazette du Canada du 1er décembre 1979 comme suit:

> L'hexachlorobenzène est un sous-produit de plusieurs procédés de l'industrie chimique, il est rémanent et peut s'accumuler dans les tissus. A l'échelle nationale, sa concentration dans certaines parties de l'environnement diminue et ne constitue pas un problème immédiat. Par conséquent, la réglementation n'est pas encore nécessaire. Le contrôle des sources ponctuelles et de l'ensemble de l'environnement est toujours nécessaire, et l'on doit s'efforcer de réduire davantage l'entrée de ces substances dans l'environnement.

## FOREWORD

Hexachlorobenzene is a persistent organochlorine compound that was first found in the Canadian environment in 1970. During the past decade it has posed a continuing health and environmental concern because of its ubiquitous occurrence and cumulative properties. Thus, in 1976, when the List of Priority Chemicals was compiled for the Environmental Contaminants Program, hexachlorobenzene joined other persistent organochlorine compounds, such as polychlorinated biphenyls (PCBs) and mirex, as the first compounds to be investigated in detail.

In April 1978, two reports were prepared for the DOE/NH&W Environmental Contaminants Committee. One reviewed information on the HCB situation in Canada with respect to human health and the other with respect to the environment. These two reports resulted in a Committee decision to undertake a detailed investigation of sources of HCB in the Canadian environment. The investigations as to sources of HCB were undertaken through the regional offices of the Environmental Protection Service and a national report on HCB sources was prepared from the regional reports in August 1979. This information was partially updated in January 1981.

The three documents formed the background to deliberations of the DOE/NH&W Environmental Contaminants Committee. The Committee decided that the documents and a summary of the Committee's decision should be published.

The Committee's decision was summarized in Priority Chemicals - 1979 as published in the Canada Gazette, Dec. 1, 1979:

> "Hexachlorobenzene, a waste-product of several industrial chemical processes, is persistent and can be bioaccumulated. Review of the national situation indicates that levels in the environment, some of which are decreasing, are not of immediate concern. Regulatory action is, therefore, not presently warranted. Point source and general environmental monitoring are still needed and efforts to further reduce entry of HCB into the environment must continue."

When the NH&W Report was submitted to the DOE/NH&W Committee, it was not anticipated that the Report would be published. NH&W is to publish a document on HCB in 1982, which will be a major revision and expansion of the subject areas and material presented in Section One. The document will provide a more complete coverage of HCB from the environmental health aspect.

**ACKNOWLEDGEMENTS**

The first report, on health aspects, was prepared by M.E. Meek and D.C. Villeneuve, Bureau of Chemical Hazards of the Environmental Health Directorate, Health and Welfare Canada. The second and third reports were prepared by Michael Gilbertson, Contaminants Control Branch, Environmental Protection Service, Environment Canada. The third report, on sources, was prepared from EPS regional reports prepared by Ian Traverse, Altantic Region; Hospice Alves, Quebec Region; David Pascoe, Ontario Region; Paul Fee, Northern and Western Region and Douglas Wilson, Pacific and Yukon Region. Ian McBeath contributed his extensive knowledge of the chlor-alkali industry. Information on the chlor-alkali sector in the third report was updated (January 1981) by Wayne Bisset, Water Pollution Control Directorate, Environmental Protection Service.

## TABLE OF CONTENTS


| | | Page |
|---|---|---|
| ABSTRACT | | i |
| RÉSUMÉ | | ii |
| FOREWORD | | iii |
| ACKNOWLEDGEMENTS | | iv |
| LIST OF TABLES | | vii |
| 1 | HEXACHLOROBENZENE: BACKGROUND DOCUMENT ON THE SITUATION IN CANADA WITH RESPECT TO HUMAN HEALTH (Report No. 1) | 1 |
| 1.1 | Introduction | 3 |
| 1.2 | Human Exposure to HCB | 3 |
| 1.3 | Metabolism and Toxicity | 7 |
| 1.4 | Recommendations | 9 |
| | REFERENCES | 10 |
| 2 | HEXACHLOROBENZENE: BACKGROUND DOCUMENT ON THE ENVIRONMENTAL SITUATION IN CANADA (Report No. 2) | 13 |
| 2.1 | Properties of HCB | 15 |
| 2.2 | Uses of HCB | 15 |
| 2.3 | History of HCB Contamination | 16 |
| 2.3.1 | HCB in Canada | 18 |
| 2.4 | HCB in the Literature | 19 |
| 2.5 | Production of Hexachlorobenzene | 20 |
| 2.6 | Extent of HCB Contamination in Canada | 21 |
| 2.7 | Recommendations | 23 |
| | REFERENCES | 25 |
| 3 | SOURCES OF HEXACHLOROBENZENE IN CANADA (Report No. 3) | 27 |
| 3.1 | Introduction | 29 |
| 3.2 | Pacific Region (British Columbia and Yukon) | 32 |
| 3.2.1 | Chlor-alkali Plants | 33 |
| 3.2.2 | Sodium Chlorate Plants | 35 |
| 3.2.3 | Other Industries | 36 |

| | | Page |
|---|---|---|
| 3.3 | Northwest Region (Alberta, Saskatchewan, Manitoba and the Northwest Territories) | 37 |
| 3.3.1 | Chlor-alkali Plants | 37 |
| 3.3.2 | Sodium Chlorate Plants | 39 |
| 3.3.3 | Other Industries | 39 |
| 3.4 | Ontario Region | 39 |
| 3.4.1 | Chlor-alkali Plants | 40 |
| 3.4.2 | Sodium Chlorate Plants | 43 |
| 3.4.3 | Organic Chemicals Plants | 44 |
| 3.4.4 | Other Industries | 44 |
| 3.4.5 | Other Information | 44 |
| 3.5 | Quebec Region | 44 |
| 3.5.1 | Chlor-alkali Plants | 45 |
| 3.5.2 | Sodium Chlorate Plants | 46 |
| 3.5.3 | Organic Chemicals Plants | 47 |
| 3.5.4 | Other Industries | 48 |
| 3.6 | The Altantic Region (Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick) | 50 |
| 3.6.1 | Chlor-alkali Plants | 50 |
| 3.6.2 | Sodium Chlorate Plants | 51 |
| 3.6.3 | Other Industries | 51 |
| 3.7 | Pesticides | 51 |
| 3.8 | Discussion and Recommendations | 53 |
| REFERENCES | | 55 |
| APPENDIX | ANALYSIS OF CROSS CHECK SAMPLES FOR HCB | 57 |

## LIST OF TABLES


| Table | | Page |
|---|---|---|
| 1.1 | HEXACHLOROBENZENE IN SELECTED FOODSTUFFS | 4 |
| 1.2 | HEXACHLOROBENZENE IN DAIRY MILK | 4 |
| 1.3 | HEXACHLOROBENZENE IN HUMAN ADIPOSE TISSUE AND FAT | 6 |
| 1.4 | HEXACHLOROBENZENE IN HUMAN MILK | 7 |
| 2.1 | PCB AND HCB RESIDUES IN HUMAN ADIPOSE TISSUES µg/g FAT WEIGHT BASIS | 17 |
| 2.2 | ORGANOCHLORINE RESIDUE LEVELS IN HERRING GULL EGGS FROM COLONIES IN THE GREAT LAKES - 1974 AND 1975 | 19 |
| 2.3 | HEXACHLOROBENZENE IN LAKE ONTARIO FISH - 1977 | 20 |
| 2.4 | LEVELS OF HEXACHLOROBENZENE IN EFFLUENTS | 22 |
| 2.5 | LEVELS OF HEXACHLOROBENZENE IN VARIOUS KINDS OF SEDIMENTS AND SOILS | 24 |
| 3.1 | CHLOR-ALKALI PLANTS IN CANADA - 1979 | 31 |
| 3.2 | SODIUM CHLORATE PLANTS IN CANADA - 1979 | 31 |
| 3.3 | ORGANIC CHEMICALS AND SITES OF POSSIBLE PRODUCTION OF HCB IN CANADA - 1979 | 32 |
| 3.4 | HCB IN PESTICIDES SAMPLED IN THE PACIFIC REGION | 52 |
| 3.5 | HCB IN PESTICIDES SAMPLED IN THE QUEBEC REGION (1978) | 52 |
| A.1 | COMPARATIVE ANALYSES FOR HCB CONTAMINATION | 59 |

# HEXACHLOROBENZENE

Background Document on the Situation in Canada
With Respect to Human Health

for

DOE/NH&W Environmental Contaminants Committee

M.E. Meek, D.C. Villeneuve
Bureau of Chemical Hazards
Environmental Health Directorate
Ottawa, Ontario
K1A 0L2
April 25, 1978

## 1.1 Introduction

Hexachlorobenzene (HCB) has been used as a fungicidal seed dressing for a variety of cereal crops. It is formed in substantial quantities as a waste by-product of various chemical processes, and is often present as a contaminant in pesticides such as pentachloronitrobenzene and Dacthal. HCB has been implicated as the causative agent in cases of human poisoning in Turkey (1955-59), and Saudi Arabia (late 1960's), and its presence in air, food and water has been reported in various parts of the world.

## 1.2 Human Exposure to HCB

Residues of hexachlorobenzene have been found in food, most often in meat and dairy products. Levels detected in 15 food commodities available in Canada including various dairy products, meat, fruits and vegetables ranged from 0.01 to 0.035 mg/kg (National Health and Welfare, unpublished data, 1972-76).

In the 1975-76 and 1976-77 sampling periods, concentrations above 0.1 mg/kg were detected only in some imported cheeses. In the U.S., HCB was found to be present at levels ranging from 0.008-0.032 mg/kg (Corneliussen, 1972) and 0.01 to 0.02 mg/kg (Johnson and Manske, 1976) in food composites collected from various cities during the periods June 1969 to April 1970 and August 1972 to July 1973, respectively. Levels of HCB recorded in various foodstuffs in other countries are presented in Table 1.1.

The mean concentration of hexachlorobenzene reported in the dairy milk supply of 11 counties in southern Ontario was 0.28 µg/L (Frank et al., 1975). Residues ranged from a low of none detected in milk from Essex and Haldimand counties to a high of 0.44 µg/L from Brant and Wentworth. It has been estimated on the basis of this data that approximately 0.15 kg of HCB was present in the entire annual milk supply for the 11 county region. Levels of HCB determined in the milk supply of various regions are presented in Table 1.2; concentrations reported for Ontario are considerably less than those found in some countries.

Estimates of the total intake of HCB in food vary considerably. Based on the analysis of composite diets, the average daily individual consumption of HCB in food studied in Toronto (1973) was estimated to be 7.09 µg (National Health and Welfare, 1972-76). Intake in Canadian food is considerably less than a maximum allowable daily intake calculated on the basis of the World Health Organization (WHO) guideline which suggested the upper limits for residues of HCB in food (0.6 µg/kg/day for a

TABLE 1.1 HEXACHLOROBENZENE IN SELECTED FOODSTUFFS

| Foodstuff | Country | HCB Concentration (mg/kg) | Reference |
|---|---|---|---|
| Edible Fish | U.S. | 0.045 (<0.010-0.34) | Johnson et al., 1974 |
| | Italy | 0.0007 (n.d.-0.0018) | Heenschen et al., 1976 |
| Eggs | Australia | 0.3 (<0.01-4.85) | Siyali, 1972 |
| | Italy | 0.0047 (0.0017-0.0075) | Leoni and D'arca, 1976 |
| Animal Fat | European Community - beef | 0.46 (<0.01-0.87) | EEC, 1974 |
| | - pork | 0.03 (<0.01-0.11) | |
| | Italy - pork | 0.096 (0.0743-0.118) | Leoni and D'arca, 1976 |
| | - chicken | 0.049 (n.d.-0.075) | |
| Butter | Germany | 0.078 (0.01-0.26) | Heenschen et al., 1976 |
| | Italy | 0.133 | Leoni and D'arca, 1976 |
| Cheese (fat basis) | Germany | 0.064 (0.01-0.26) | Heenschen et al., 1976 |
| | Italy | 0.063 (n.d.-0.126) | Leoni and D'arca, 1976 |

TABLE 1.2 HEXACHLOROBENZENE IN DAIRY MILK

| | Number of samples | HCB Concentration (μg/L) | Reference |
|---|---|---|---|
| Canada | 51 | <2[a] | Unpublished data, National Health and Welfare, 1978 |
| Southern Ontario | 147 | 0.28 (n.d. - 0.44)[a] | Frank et al., 1975 |
| Germany | 167 | 3.96 (0.4 - 20)[a] | Heenschen et al., 1976 |
| Australia | 198 | (<1 - 5) | Siyali and Stricher, 1973 |
| France | 9 | (2 - 44) | Acker and Schulte, 1970 |
| Italy | 63 | 4.2 (0.2 - 17.2) | Leoni and D'arca, 1976 |

[a] - calculated from residues on fat basis assuming the fat content of milk to be 4%

70 kg man = 42 µg/day). In a total diet study conducted in Italy between 1969 and 1974, the average intake was calculated as 4.2 µg/kg/day (Leoni and D'arca, 1976).

No data to indicate concentrations of HCB which are present in surface water, drinking water or the air of Canadian communities were found. In the U.S., concentrations in air as high as 18.6 µg/$m^3$ within production sites and 3 µg/$m^3$ in the immediate vicinity of production sites have been recorded (EPA, 1977). The maximum concentration detected outside of production sites was 3 µg/$m^3$ (EPA, 1977). Based on a review of available data, the average concentration in rural air is approximately 0.2 ng/$m^3$.

For surface water, mean concentrations of 0.0025 µg/L (n.d. - 0.025) in Italy Leoni and D'arca, 1976) and 0.130 µg/L (0.01-0.520) in Holland (Greve, 1972) have been reported. In the U.S., the HCB content of water taken from a contaminated area of Louisiana was generally less than 2 µg/L (Laska et al., 1976). In other areas of the U.S., HCB has been detected at 0.010 µg/L in raw and 0.006 µg/L in finished drinking water (National Academy of Science (NAS), 1977). Intake of hexachlorobenzene from drinking water (2 L/day), therefore, can be considered to be negligible in comparison to intake from food.

HCB residues have been detected in human blood, milk and adipose tissues. Levels recorded in human adipose tissues and fat, in various parts of the world, are recorded in Table 1.3. The mean level of hexachlorobenzene reported in the adipose tissues of Canadians was 0.062 mg/kg (Mes et al., 1977). Levels shown in this study were similar to concentrations measured in adipose tissues of residents of Japan (Curley et al., 1973). In Ontario, mean levels of 0.09 mg/kg and 0.12 mg/kg in samples of abdominal fat were recorded for 1971-72 and 1973-74 sampling periods, respectively (Holdrinet et al., 1977). The residues are generally lower than those found in human fat in other countries.

Levels of HCB reported in human milk are presented in Table 1.4. In Canada, the average concentration is 2 µg/L (Mes and Davies, 1979), which is considerably less than values reported for other countries. On the basis of these data, the average daily HCB intake from mothers' milk of a suckling infant in Canada would be 0.28 µg/kg (intake of milk for a 5 kg child = 700 mL), or as high as 0.5 µg/kg (fat content of mothers milk = 2.2% intake of fat per day from mother's milk = 5.5 g/kg of body weight). For the non-occupationally exposed population, breast-fed infants are at greatest risk, because of their small size and contamination of their food supply. A 5 kg infant would ingest, on the average, 0.58 µg/kg HCB per day, which is less than the WHO guideline for setting upper

TABLE 1.3 HEXACHLOROBENZENE IN HUMAN ADIPOSE TISSUE AND FAT

| | Number of Samples | HCB Concentration (mg/kg) | Reference |
|---|---|---|---|
| Adipose Tissue | | | |
| Canada | 172 | 0.062 (0.001-0.529) | Mes et al., 1977 |
| Ontario | 57 | 0.060 | |
| Quebec | 50 | 0.107 | |
| Central (Man. Sask.) | 22 | 0.015 | |
| Western (Alta, B.C.) | 27 | 0.043 | |
| Eastern (Nfld, P.E.I., N.S., N.B.) | 16 | 0.025 | |
| Japan | 241 | 0.08(<0.030-0.77) | Curley et al., 1973 |
| Fat | | | |
| Ontario | 33 | 0.09 (n.d. -0.50) | Holdrinet et al., 1977 |
| | 76 | 0.12 (n.d. -0.43) | |
| Japan | 15 | 0.21 (0.10-0.42) | Morita et al., 1975 |
| Germany | 20 | 6.3 | Acker and Schulte, 1970 |
| | 93 | 4.80 (0.11-21.80) | Schulte, 1971 |
| Australia | 81 | 1.31 (<0.01-8.20) | Siyali, 1972 |
| United Kingdom | 201 | 0.05 (n.d. -0.29) | Abbott et al., 1972 |
| Italy | 28 | 0.49 (0.13-1.36) | Leoni and D'arca, 1976 |
| Luxembourg | 25 | 1.96 (0.78-3.90) | EEC, 1974 |
| New Guinea | 38 | 0.26 (0-2.80) | Siyali, 1972 |

limits for residues of HCB in food (0.6 µg/kg body weight). This guideline, however,was established for adults; suckling infants may be more susceptible to HCB.

The average concentration of HCB in the blood of non-occupationally exposed individuals in Australia was 22 µg/L (0-95) (Siyali, 1972); in German children upper levels of 22 µg/L in boys and 17 µg/L in girls were reported (Richter and Schmid, 1976). Levels recorded in a Louisiana population exposed through transportation and disposal of chemical wastes containing HCB averaged 3.6 µg/L (n.d.-23); the highest concentration recorded was 345 µg/L in a waste disposal facility worker (Burns and Miller, 1975). Residues of HCB in the blood of vegetable spraymen exposed to HCB-contaminated Dacthal averaged 40 µg/L (0-310) (Burns et al., 1974).

TABLE 1.4 HEXACHLOROBENZENE IN HUMAN MILK

| Human Milk | Number of Samples | HCB Concentration µg/L (whole milk) and µg/L (milk fat) | Reference |
|---|---|---|---|
| Whole Milk | | | |
| Canada | 100 | 2 (n.d.-21) | Mes and Davies, 1979 |
| Ontario | 35 | 2 | |
| Atlantic Provinces | 10 | 1 | |
| Australia | 45 | 16 (2-79) | Siyali, 1973 |
| | 68 | 51 (2-330) | Newton and Greene, 1972 |
| Germany | 43 | 153 | Schulte, 1971 |
| Sweden | | 1 | Tuinstra, 1971 |
| France | 49 | 53 (11-170) | EEC, 1974 |
| Luxembourg | 12 | 560 (110-2 160) | EEC, 1974 |
| Milk Fat | | | |
| Ontario | 14 | 0.10 (n.d.-0.25) | Holdrinet et al., 1977 |
| Germany | 43 | 5.3 (0.43-12) | Acker and Schulte, 1970 |
| U.S. | 1 436 | 0.078 (0.05-0.1)[b] | Savage, 1978 |
| | | Maximum 14 | |

b - range of means for different regions of the country

## 1.3 Metabolism and Toxicity

HCB is extremely persistent in the environment; the half-life in soil is estimated to be 969 days (Beck and Hansen, 1974). The half-life in rats was 60 days (Morita and Oishi, 1975); in sheep adipose tissue, the half-life for HCB was 16 weeks (Avrahami and Steele, 1972). In animals, hexachlorobenzene undergoes limited metabolism to form other chlorinated benzenes or pentachlorophenol (Mehendale et al., 1975; Lui and Sweeney, 1975; Koss and Koransky, 1975; and Koss et al., 1976).

HCB appears to have a low single dose lethality in animals, which may be due to poor absorption from the gastrointestinal tract or the site of injection (Gehring and MacDougall, 1975). HCB, however, has a high cumulative toxicity; in animals, it causes hepatomegaly, porphyria, proliferation of the smooth endoplasmic reticulum (SER) and induction of drug metabolizing enzymes. The no-effect level for porphyria in the quail,

the most sensitive species, is 0.1 mg/kg/day (Vos et al., 1971). The no-effect level for enzyme induction and proliferation of the SER in the rat is 0.5 mg/kg/day. HCB intoxication in animals is accompanied by neurotoxic manifestations, trembling, ataxia and paralysis (Gehring and MacDougall, 1971). Histological alterations include increased hepatocyte size and proliferation of the SER (Kuiper-Goodman et al., 1974). At higher dose levels (0.35 mg/kg/day in diet for 67 days), HCB produced cytoplasmic vacuolation and tubular inclusions in hepatic cells (Timme et al., 1974). Other studies showed hyperplasia of the adrenal cortex and lung degeneration in rats fed 100 ppm HCB in the diet for 4 months (5 mg/kg/day) (Kimbrough and Linder, 1974).

The no-effect level for reproductive parameters in a multigeneration study of rats was 40 ppm (Grant et al., 1975). HCB is not teratogenic in the rat (Khera, 1974), but has caused cleft palates and some kidney malformations in mice administered 100 mg/kg on days 7-15 of gestation (Courtney et al., 1976). HCB did not produce any dominant lethal effects at levels as high as 60 mg/kg (Khera 1974).

An important observation made in one study is that rats, suckling a mother treated with HCB, died in the absence of untoward effects in the mother (De Matteis et al., 1961). In the same study, it was shown that young taken from an untreated mother and fostered by treated mothers also died. This suggests the possibility of increased susceptibility of the young to HCB and/or the presence of a toxic metabolite in the milk.

Hexachlorobenzene has been shown to be carcinogenic in the hamster, producing both liver and thyroid tumours (Cabral et al., 1977). For this study the no-effect level was estimated to be 4-16 mg/kg/day.

## 1.4 Recommendations

It is well recognized that the presence of hexachlorobenzene in the environment constitutes a potential hazard to health. Review of available data indicates, however, that levels to which Canadians are exposed, at present, are not excessively high; therefore, HCB should not be considered an immediate concern. Investigation of the following areas is warranted in order to allow a more thorough evaluation of the health implications of the presence of HCB in the Canadian environment:

1. Levels in food, human fat tissues and particularly in mothers' milk in Canada should be monitored further. Studies to investigate the occurrence of HCB in air, water and human blood are required.

2. Animal studies are required to determine the cause of neonatal susceptibility to HCB and to establish a no-effect level in suckling infants.
3. Initiation of pharmacokinetic and metabolism studies in the hamster would be desirable, since hexachlorobenzene has been shown to be carcinogenic in this species.

**REFERENCES**

Abbott, D.C., G.B. Collins, and R. Goulding, Brit. Med. J., 2: 553 (1972).

Acker, L. and E. Schulte, Naturwissenschaft, 10: 497 (1970).

Acker, L. and E. Schulte, Naturwissenschaft, 57: 497 (1970).

Avrahami, M. and R.T. Steele, N.Z. J. Agric. Res., 15: 476 (1972).

Beck, J. and K.E. Hansen, Pestic. Sci., 5: 41 (1974).

Burns, J.E. and F.M. Miller, Arch. Environ. Health, 30: 44 (1975).

Burns, J.E., F.M. Miller, E.D. Gomes and R.A. Albert, Arch. Environ. Health, 29: 192 (1974).

Cabral, J.R.L., P. Shubik, T. Mollner and F. Raitano, Nature, 269: 510 (1977).

Corneliussen, P.E. Pesticides Monit J., 5: 313 (1972).

Courtney, K.D., M.F. Copeland and A. Robbins, Toxicol. Appl. Pharmacol., 35: 239 (1976).

Curley, A., V.W. Burse, R.W. Jennings and E.C. Villaneuva, Nature, 242: 338 (1973).

De Matteis, F., B.E. Prior and C. Rimington, Nature, 191: 363 (1961).

E.E.C. Commission of the European Communities, "A European Community Study on the Determination of Organochlorine Pesticide Residues in Fatty Materials," In European Colloquium, Problems Raised by the Contamination of Man and His Environment by Persistent Pesticides and Organo-Halogenated Compounds, Luxembourg (May 14-16, 1974).

E.E.C. Commission of the European Communities, "Pesticide Residues in Human Fat and Human Milk in the Nine Member States of the European community (1969-1973)," In European Colloquium, "Problems" Raised by the Contamination of Man and His Environment by Persistent Pesticides and Organo-Halogenated Compounds, Luxembourg (May 14-16, 1974).

Frank, R., E.H. Smith, H.E. Braun, M. Holdrinet and J.W. McWade, J. Milk Food Technol., 38: 65 (1975).

Gehring, P.J. and P. MacDougall, Review of the Toxicity of Hexachlorobenzene and Hexachlorobutadiene, Dow Chemical, U.S.A. (1971).

Grant, D.L., G.V. Hatina and W.E.J. Phillips, Toxicol. Appl. Pharmacol., 33: 167 (1975).

Greve, P.A., Science Total Environ., 1: 173 (1972).

Heenschen, W., A. Bluthgen and A. Tolle, Zentralbl. Bakteriol., 162: 188 (1976).

Holden, A.V., Pesticides Monit. J., 4: 117 (1970).

Holdrinet, M.V.H., H.E. Braun, R. Frank, G.J. Stopps, M.S. Smout and J.W. McWade, Can. J. Public Health, 68: 74 (1977).

Johnson, J.L., D.L. Stalling and J.W. Hogan, Bull. Environ. Contam. Toxicol., 11: 393 (1974).

Johnson, R.D. and D.O. Manske, Pesticide Monit. J., 9: 157 (1976).

Khera, K.S., Food Cosmet. Toxicol., 12: 471 (1974).

Kimbrough, R.D. and R.E. Linder, Res. Commun. Chem. Pathol. Pharmacol., 8: 653 (1974.)

Koss, G. and W. Koransky, Arch. Toxicol., 34: 203 (1975).

Koss, G., W. Koransky and K. Steinbach, Arch. Toxicol., 35: 107 (1976).

Kuiper-Goodman, T., O. Grant, G. Korsrud, C.A. Moodie and I.C. Munro, Toxicol. Appl. Pharmacol., 29: 101 (1974) (Abst.).

Laska, A.L., C.K. Bartell and J.L. Laseter, Bull. Environ. Contam. Toxicol., 15: 535 (1976).

Leoni, V. and S.U. D'arca, Science Total Environ., 5: 253 (1976).

Lui, H. and G.D. Sweeney, F.E.B.S. Lett., 51: 225 (1975).

Mehendale, H.M., M. Fields and H.B. Matthews, J. Agric. Food Chem., 23: 261 (1975).

Mes, J., D.S. Cambbell, R.N. Robinson and D.J.A. Davies, Bull. Environ. Contam. Toxicol., 17: 196 (1977).

Mes, J. and D. Davies, Bull. Environ. Contam. Toxicol., 21:381-387 (1979).

Morita, M., S. Mimura, G. Ohi and H. Yagyu, Env. Pollution, 9: 175 (1975).

Morita, M. and S. Oishi, Bull. Environ. Contam. Toxicol., 14: 313 (1975).

National Academy of Sciences, Safe Drinking Water Committee, Advisory Center on Toxicology Assembly of Life Sciences, National Research Council, Drinking Water and Health, Part II, U.S. National Academy of Sciences, Washington, D.C. (1977).

National Health and Welfare Canada, unpublished data from the Food Directorate, Health Protection Branch (1978).

Newton, K.G. and N. Greene, Pesticides Monit. J., 6: 4 (1972).

Richter, E. and A. Schmid, Arch. Toxicol., 35: 141 (1976).

Savage, E.P., U.S. EPA Contract No. 68-101-3190 Unpublished data (1978).

Schulte, E., Inaugural dissertation Universitat Munster (1971).

Siyali, D.S. Med. J. Aust., 2: 1063 (1972).

Siyali, D.S. Med. J. Aust., 2: 815 (1973).

Siyali, D.S. and P. Stricker, Aust. J. Dairy Technol. June 55 (1973).

Timme, A.H., J.J.F. Taljaard, B.C. Schanley and S.M. Joubert, S'Afr. Med. J., 48: 1833 (1974).

Tuinstra, L.G.N., Milk Dairy, J., 25: 24 (1971).

U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, Industrial Pollution Control Division, Status Assessment of Toxic Chemicals, Hexachlorobenzene, U.S. (September 6, 1977).

Vos, J.G., H.L. Van der Maas, A. Musch and E. Ram, Toxicol. Appl. Pharmacol., 18: 944 (1971).

# HEXACHLOROBENZENE

Background Document on the Environmental Situation in Canada

for

DOE/NH&W Environmental Contaminants Committee

M. Gilbertson
Contaminants Control Branch
Environmental Impact Control Directorate
Environmental Protection Service
Ottawa, Ontario
K1A 1C8

April 1, 1978

## 2.1 Properties of HCB

Hexachlorobenzene (HCB) is a white powder with an empirical formula $C_6Cl_6$ and a molecular weight of 284.8. It is formed as a by-product of the manufacture of chlorinated solvents and is recovered for commercial use. It is also formed in other industrial chemical processes such as the electrolytic production of chlorine and the manufacture of certain pesticides such as Dacthal, Atrazine, Propazine, Simazine, Pentachloronitrobenzene and Mirex.

Hexachlorobenzene is an extremely persistent substance and is not degraded by photolysis, hydrolysis or by other physicochemical or biological processes in the environment. In this respect it behaves like several other organohalogen substances such as DDE, PCBs, Mirex and PBBs.

Hexachlorobenzene is bioaccumulated in Daphnia magna (water flea) and in bluegills (Lepomis macrochirus) fed contaminated Daphnia magna (Schoettger, 1972). In trout muscle, the bioconcentration factor of HCB was close to that of tetrachlorobiphenyl (Neely et al., 1974). Similarly, studies with sheep (Craig and Dwyer, 1961), chickens (Watts, 1968), pigs (Gardiner and Armstrong, 1960), Japanese Quail (Vos et al., 1971) and kestrels (Vos et al., 1972) showed that HCB is assimilated from food, stored in lipids and excreted only very slowly.

HCB disperses in the environment when it is released. It has a high activity coefficient in aqueous solution and tends it to vaporize out of water (Mackay and Wolkoff, 1973). It also sublimes readily and will evaporate if exposed to air. This aerial dispersion may be a major pathway for movement of HCB into the environment, both aquatic and terrestrial. HCB has a very low solubility in water but may be adsorbed to suspended particles. Movement of sediment containing HCB may be a significant transport mechanism in the aquatic environment.

## 2.2 Uses of HCB

Hexachlorobenzene was introduced into agriculture as a fungicide for seed and cereal treatment in 1945 (Yershin, 1945). Later it was found to be particularly effective against bunt and dwarf bunt of wheat (Lansade, 1949). HCB is not registered in Canada at present, but the use is listed with the Canada Department of Agriculture as acceptable for registration because there are no registered alternative substances.

## 2.3 History of HCB Contamination

In 1955, an outbreak of a cutaneous type of porphyria occurred in Turkey resulting in 3 000 to 5 000 cases (Cam and Nygogosyan, 1963). The disease was traced to the consumption of wheat containing 2 g/kg HCB and led to extensive research on human health effects of hexachlorobenzene. Porphyria is a manifestation of a disturbance in heme biosynthesis which leads to an increase in the synthesis, accumulation and excretion of porphyrins which are intermediates in the synthesis of heme, hemoglobin, myoglobin, cytochromes and various enzymes. The victims were mostly children between the ages of 6 to 15; they exhibited blistering and epidermolysis of the skin, hyperpigmentation, hypertrichosis, interphalangeal arthritis, liver enlargement and porphyrin imbalance.

During the late 1960s several countries reported that hexachlorobenzene was being found in commercial wheat samples and in processed dairy products. The source of HCB was believed to be treated seed.

World-wide concern with HCB became serious enough to warrant consideration of the problem by the Food and Agriculture Organization-World Health Organization (FAO-WHO, 1970). In 1969, WHO proposed interim recommendations for HCB tolerances in a number of foodstuffs, including 1.0 ppm in the fat of meat and poultry, 0.3 ppm in fat content of dairy products, 0.01 ppm in cereal products, and 1.0 ppm in eggs (shellfree basis). It was recognized at that time that sufficient information on the effects of HCB was not available. The WHO recommendations expired on July 1, 1973.

In 1971 the United States Department of Agriculture, using a new method of analysis, identified HCB as a contaminant of hams imported from the Netherlands. By the end of 1972, imported products from Germany, Spain, Yugoslavia, Poland and Argentina had been identified as being in violation of USDA's action level of 0.3 ppm. Residues below the action level were found in products from many other countries, as well.

In 1972, analysis of meat samples by the United States Department of Agriculture revealed residues of hexachlorobenzene in the fat of beef carcasses from Louisiana and sheep from California. In Louisiana, the source of the contamination was "hex" waste from a perchloroethylene plant. The waste was transported 12 miles to a landfill site in open trucks contaminating pastures through aerial dispersion. The California situation was traced to the use of the herbicide Dacthal which contained about 10% HCB. Sheep grazing the pasture, which had been treated for several years, ingested the hexachlorobenzene.

Surveys in several countries have revealed that hexachlorobenzene is a frequent contaminant of human tissues. Highest mean levels reported were in Germans with 5.4 ppm in adipose tissues (Acker and Schulte, 1971). Australians had a mean level of 1.31 ppm (Siyali, 1972). A survey of Canadians revealed levels of 0.062 ppm (Mes et al., 1977). The levels of PCBs and HCB present in human adipose tissues of Canadians by provinces are shown in Table 2.1. The levels in Quebec residents were about twice those in Ontario residents. Levels in other provinces were lower. HCB ranges from about 3% (central) to 11% (Quebec) of the PCB present in adipose tissue.

TABLE 2.1 PCB AND HCB RESIDUES IN HUMAN ADIPOSE TISSUES (µg/g Fat Weight Basis)

| | PCBs (Task Force Report) | HCB (Mes et al., 1977) |
|---|---|---|
| Atlantic | 0.727 | 0.025 |
| Quebec | 0.969 | 0.107 |
| Ontario | 1.070 | 0.060 |
| Central | 0.499 | 0.015 |
| Western | 0.898 | 0.043 |

Hexachlorobenzene is excreted in human milk. Samples from Germany contained 5.3 ppm HCB (Acker and Schulte, 1971) and those from Australia contained 1.53 ppm HCB (Newton and Greene, 1972) on a milk fat basis. Breast-fed infants are the critical receptors of the human population not occupationally exposed to HCB.

A considerable amount of research into the toxicological effects of hexachlorobenzene was stimulated by the WHO review (FAO-WHO, 1970). The effects noted in the Turkish incident - liver enlargement, porphyria and weanling mortality - were duplicated in animal studies. In addition, rat studies indicated that hexachlorobenzene was teratogenic (Khera, 1974) and experiments with hamsters indicated that the substance was carcinogenic (Cabral et al., 1977).

In 1974, the OECD Chemicals Group agreed to collate information on hexachlorobenzene use in member countries, because of the widespread occurrence of residues in food in international trade. In 1975, the report (OECD, 1975) of this preliminary enquiry concluded that:

a) HCB is a chemical which is environmentally persistent and able to accumulate in living organisms;
b) The use of HCB as a fungicide in agriculture is now discouraged or regulated, and substitute fungicides are being increasingly employed;
c) There is some evidence that significant sources of HCB in the environment are industrial processes and industrial wastes. However, there appears to be little active control over such sources;
d) Comprehensive data on the quantities of HCB that are manufactured, used and disposed of, are not at present available through the OECD countries.

The Chemicals Group suggested that the following actions might be considered by member countries:

a) a survey of disposal methods;
b) development of comprehensive statistical data on the manufacture, use, and disposal of HCB;
c) collation and comparison of the monitoring of environmental levels of HCB; and
d) substitution of fungicides that are environmentally less harmful.

2.3.1 **HCB in Canada.** Hexachlorobenzene was first documented in the Canadian environment by two different researchers working independently. Zitko (1971) reported that a small amount of hexachlorobenzene was present in most samples of marine and freshwater fish from the maritime provinces collected for a pesticide and PCB survey in 1970. In the same year Common Terns (Sterna hirundo), nesting in island colonies at Hamilton Harbour, Ontario, were found to have laid eggs containing HCB (Gilbertson and Reynolds, 1972). In both cases the sources of hexachlorobenzene were not known. Table 2.2 shows the mean levels of DDE, HCB, PCBs and mirex in Herring Gull (Larus argentatus) eggs from Great Lakes colonies. The levels of HCB were fairly uniform between lakes, except Lake Michigan, where a lower level was determined. Lake Ontario gull eggs had the highest levels at about 0.19 ppm. HCB levels were about 0.2% those of PCBs in eggs. In Lake Ontario eggs, HCB levels were about 4% of mirex present, but in eggs from colonies in the other lakes levels were about 17% (Lake Superior) to 35% (Lake Erie) those of mirex. Lake Ontario is the only lake is into which mirex has been discharged. Contamination of Herring Gull eggs in the upper lakes probably results from adult migration and wintering in Lake Ontario.

TABLE 2.2 ORGANOCHLORINE RESIDUE LEVELS[a] IN HERRING GULL EGGS FROM COLONIES IN THE GREAT LAKES - 1974 AND 1975

| | N | DDE | HCB | PCB | Mirex |
|---|---|---|---|---|---|
| Lake Ontario | 39 | 22.6 (8.8-35.1) | 0.19 (0.01-0.72) | 142 (73.8-261) | 5.06 (1.95-18.6) |
| Lake Erie | 42 | 7.04 (3.8-14.3) | 0.11 (0.06-0.31) | 65.8 (41.2-110) | 0.31 (0.14-2.19) |
| Lake Huron | 40 | 13.8 (5.4-4.19) | 0.14 (0.05-0.42) | 51.5 (15.4-118) | 0.56 (0.06-6.92) |
| Lake Superior | 39 | 18.6 (8.6-47.1) | 0.11 (0.02-0.33) | 60 (33.4-148) | 0.66 (0.2-5.17) |
| Lake Michigan[b] | 10 | 31.8 (15.8-145) | 0.04 (0.02-0.14) | 91.3 (55.1-395) | tr. (tr.-2.47) |

a - median (range) in ppm, wet weight
b - from a single colony, 1975 only; all others from 2 colonies/lake in both years

The use of hexachlorobenzene as a seed-treatment fungicide in the Netherlands was associated with high residue levels and with mortality among predatory birds (Vos et al., 1968). In Canada, hexachlorobenzene, as well as other organochlorine substances, was associated with porphyria in unhatched Herring Gull chicks taken from Lake Ontario colonies exhibiting high embryonic mortality (Gilbertson and Fox, 1977). The hexachlorobenzene and other contaminants present in the eggs were accumulated by the adults from Lake Ontario fish.

The levels of HCB in fish from Lake Ontario in ppb whole body basis are shown in Table 2.3. About 70 ppb was found in Chinook Salmon (Oncorhynchus tshawytscha) and 80 ppb in Lake Trout (Salvelinus namaycush). HCB is about one hundredth of the level of PCB and about a third of the level of mirex in Lake Trout. In Smallmouth Bass HCB levels are about 0.36% those of PCBs and 10% those of mirex.

## 2.4 HCB in the literature

Hexachlorobenzene has been extensively reviewed in recent years. Two companies, Dow Chemical (Gehring and MacDougall, 1971) at Midland, Michigan, and Hooker Chemical and Plastics Corp. (1976) have reviewed the toxicological effects because of their involvement in the inadvertent production of HCB in their chemical manufacturing processes. The U.S. Environmental Protection Agency (1973) prepared a

TABLE 2.3 HEXACHLOROBENZENE IN LAKE ONTARIO FISH - 1977 (New York State Department of Environmental Conservation)

| Species | Location | Number | HCB Concentration (ppb)* | | |
|---|---|---|---|---|---|
| | | | Average | High | Low |
| Chinook Salmon | Salmon River | 4 | 70 | 140 | 10 |
| Lake Trout | Galloo Island | 126 (42 analyses) | 80 | 80 | 70 |
| Smallmouth Bass | Pultneyville | 15 | 30 | 60 | 10 |
| | Sodus Bay | 6 | 40 | 70 | 30 |
| | Fair Haven | 2 | 25 | 30 | 20 |

* whole body basis

review in response to the meat contamination situations in Louisiana and California. The National Academy of Sciences Study Panel (1975) in their document entitled "Assessing Potential Ocean Pollutants" studied the hazards of several groups of substances. Of the materials studied, only transuranic elements and hexachlorobenzene were found to be clear potential problems.

## 2.5 Production of Hexachlorobenzene

In Canada, HCB is not produced as a product by the chemical industry but may be produced inadvertently as a waste-product of chemical manufacturing. Hexachlorobenzene is formed in the production of various chlorinated solvents such as perchloroethylene, trichloroethylene and carbon tetrachloride. Dow Chemical of Canada Ltd. produces all three of these substances at Sarnia, Ontario. Cornwall Chemical Ltd. at Cornwall, Ontario, makes carbon tetrachloride. Canadian Industries Ltd. made trichloroethylene at Shawinigan, Quebec.

Hexachlorobenzene may be formed during the electrolytic production of chlorine in plants which use graphite anodes. In Canada, there is an extensive chlorine industry and details are being compiled by the Environmental Protection Service (EPS), Environment Canada.

The critical region of Canada for HCB levels in the environment is probably the St. Lawrence-Great Lakes system. In this area there were seven chlorine plants in Canada which may have been associated with the inadvertent production of HCB. Five of the seven plants, located in Ontario, have closed down. These are the Dow Chemical of Canada plant at Thunder Bay, the American Can of Canada Ltd. plant at Marathon, the Brown Forest Industries Ltd. at Espanola, the Canadian Industries Ltd. plant at Hamilton, and the Domtar plant at Cornwall. Only the Dow Chemical of Canada plant at Sarnia, and the Canadian Industries Limited plant at Cornwall are still in production in Ontario.

Canadian plants in the Great Lakes region, which are associated with the inadvertent production of HCB during the production of chlorinated solvents are Dow Chemical of Canada, Sarnia, Ontario, and Cornwall Chemical Ltd., Cornwall, Ontario.

In the United States Great Lakes region there are nine chlorine-producing plants which may be associated with inadvertent HCB production. These are the Dow Chemical plant at Midland, Michigan; the BASF Wyandotte Corp. and Pennwalt Corp. plants at Wyandotte, Michigan; the International Minerals and Chemicals Corp. and R.M.I. Co. plants at Ashtabula, Ohio; the E.I. du Pont de Nemours, Occidental Petroleum Corp., and Olin Corp. plants at Niagara Falls, New York; and the Allied Chemical Corp. plant at Solvay, (Syracuse) New York. The Hooker Chemical and Plastic Corp. plant at Niagara Falls, New York, makes perchloroethylene and may be the plant, identified by Mumma and Lawless (1975), producing carbon tetrachloride. This plant also manufactured the pesticide, mirex, which may have HCB associated with its production.

It is likely that both Canada and the U.S. have plants which are sources for HCB. The amounts which have been discharged to the Great Lakes are unknown and the amounts in the sediments near the plants have not been investigated. It should be noted that the U.S. has numerically more plants bordering the Great Lakes, than Canada with the potential to produce HCB.

## 2.6 Extent of HCB Contamination in Canada

The levels of HCB in effluents from various locations in Canada are shown in Table 2.4. In the Atlantic provinces studies have shown that a variety of industries have detectable amounts of HCB in the effluents from their plants. No data are available at present for Quebec and the Northwest regions. In Ontario, HCB is associated with electrolytic chlorine and chlorinated solvent production. About 100 kg of HCB is discharged per year from the Dow Chemical of Canada plant at Sarnia. In the Pacific region discharges from the sewer lagoons of two electrolytic plants contained HCB.

TABLE 2.4 LEVELS OF HEXACHLOROBENZENE IN EFFLUENTS

| Origin | | Hexachlorobenzene Concentration (µg/L) | Hexachlorobenzene Quantity (kg/day) |
|---|---|---|---|
| Atlantic (1977) | | | |
| Electrolytic Chlorine Production | | | |
| - CIL Dalhousie | | 0.05 | |
| - Canso Chemicals | | 0.17 | |
| Paint Manufacture | | | |
| - Laurentide Chemicals | | 1.1 | |
| Coal and Steel | | | |
| - Sydney Steel | | 0.02 | |
| - Stellarton Coal | | 0.07 | |
| Pulp and Paper | | | |
| - Fraser Companies | | 0.02 | |
| Quebec | | | |
| Data not available | | | |
| Ontario | | | |
| Electrolytic Chlorine and Chlorinated Solvents Production | | | |
| - Dow Chemical of Canada | (1971) | 2.00-14.00 | 0.02-0.14 |
| | (1976) | | 0.27 |
| - Cornwall Chemicals | (1977) | 0.007 | |
| - Domtar | (1977) | 0.005 | |
| Northwest | | | |
| Data not available | | | |
| Pacific (date unknown) | | | |
| Electrolytic Chlorine Production | | | |
| - FMC Chemicals | | 0.05 | 0.0014 |
| (water from sewer lagoon) | | 0.11 | |
| Electrolytic Sodium Chlorate Production | | | |
| - ERCO Industry | | 0.005 | |
| (water from sewer lagoon) | | 0.029 | |

Note: Although information in this Table is not current, it does give an indication as to levels of HCB that can be expected in effluents from specific industries.

Results of sediment and soil surveys indicate that HCB is in the environment and continues to enter the environment (see Table 2.5). Data are not available for the Atlantic, Quebec or Northwest regions. At Sarnia, 6-8 ppb has been detected in leachate from the Dow Chemical of Canada dump site. Similarly landfill sites in the Pacific region have contaminated nearby creeks and shoreline. The highest level was found in the sediment of a sewer lagoon receiving waste from the FMC plant.

Soils from various agricultural areas in BC contained substantial amounts of HCB. These were generally associated with a former seed treatment facility or nurseries but 50 samples from the Peace River contained an average level of 1.2 ppb.

## 2.7 Recommendations

Known sources of hexachlorobenzene should be investigated to determine the quantity produced and the amounts released to the environment and disposed of in landfills or by incineration. The possibility of other sources of hexachlorobenzene should be investigated through air and sediment monitoring.

TABLE 2.5 LEVELS OF HEXACHLOROBENZENE IN VARIOUS KINDS OF SEDIMENTS AND SOILS

| Area | Sediments and Soils | Level (µg/L) of HCB Present |
|---|---|---|
| Atlantic | No data available at present | |
| Quebec | No data available at present | |
| Ontario | **Electrolytic Chlorine and Chlorinated Solvents Production** | |
| | Dow Chemical of Canada (1973) | |
| | - Dump site leachate | 6.0 - 8.0 |
| Northwest | No data available at present | |
| Pacific | **Electrolytic Chlorine Production** | |
| | Hooker Chemicals (Nanaimo) | |
| | - Landfill | 108.0 |
| | - Creek sediment near landfill | 10 000.0 |
| | - Shoreline sediments near landfill | 1.5 |
| | Hooker Chemicals (N. Van) | |
| | - Landfill | 208.0 |
| | FMC Chemicals | |
| | - Landfill | 5.0 |
| | - Sewer lagoon sediment | 12 360.0 |
| | - Sediment of receiving environment | 250.0 |
| | **Electrolytic Sodium Chlorate Production** | |
| | ERCO | |
| | - Sewer lagoon sediments | 35.0 |
| | - Sediments in discharge canals | 15.0 |
| | **Agriculture** | |
| | Peace River | |
| | - Soils (50 farms) | 1.2 |
| | - Soil (seed treatment plant) | 26.5 |
| | - Sediment (near seed treatment plant) | 1.3 |
| | Lower Mainland (Surrey) | |
| | - Soil (nursery) | 13.8 |
| | Vancouver (E. Marine Dr.) | |
| | - Soils (2 farms) | 2.3 |
| | - Sediments (farm seepages) | 39.0 |
| | Vancouver Island (Duncan) | |
| | - Soil (nursery) | 6.1 |

## REFERENCES

Acker, von L. and E. Schulte, "Zum Vorkommen von Hexachlorbenzol und polychlorierten Biphenylen neben chlorierten Insektiziden in menschlichem Fettgewebe und in Human Milch," Ernahrungsforschung 16: 559-567 (1971).

Cabral, J.R.P., P. Shubik, T. Mollner and F. Raitano, "Carcinogenic Activity of Hexachlorobenzene in Hamsters," Nature 269: 510-511 (1977).

Cam, C. and G. Nygogosyan, "Acquired Porphyria Cutanea Tarda Due to Hexachlorobenzene," Journal of the American Medical Association, 183: 88-91 (1963).

Craig, J. and H.P. Dwyer, "Pickled Wheat is Safe for Sheep: HCB Treated Wheat is Safe for Sheep but Should be Fed with Caution for Short Periods Only," J. Agric. West. Australia 24(II) (Series 4): 909-12 (1961).

Environmental Protection Agency, (U.S.), Environmental Contamination From Hexachlorobenzene," report of the Office of Toxic Substances, PB-251 874 (1973).

Food and Agriculture Organization-World Health Organization (FAO-WHO), Evaluations of Some Pesticide Residues in Food, The Monographs, issued jointly by FAO-WHO, WHO/Food Add./71-42, WHO, Geneva, 600 pp. (1970).

Gardiner, M.R. and J. Armstrong, "Feeding Pickled Wheat to Pigs," J. Dept. Agr. W. Australia 1: 237-38 (1960).

Gehring, P.J. and D. MacDougall, Review of the Toxicity of Hexachlorobenzene and Hexachlorobutadiene, Chemical Biology Research, Toxicology Section, Dow Chemical, U.S.A., Midland, Michigan, 11 pp. (1971).

Gilbertson, M. and G.A. Fox," Pollutant - Associated Embryonic Mortality of Great Lakes Herring Gulls," Environmental Pollution 12: 211-216 (1977).

Gilbertson, M. and L.M. Reynolds," Hexachlorobenzene (HCB) in the Eggs of Common Terns in Hamilton Harbour, Ontario," Bull. Environ. Contamin. Toxicol. 7: 371-73 (1972).

Hooker Chemicals and Plastics Corporation, A Review of Literature Relating to the Toxicologic and Environmental Effects of i) Hexachlorobenzene and ii) Hexachlorobutadiene," prepared by Agatha Corporation, (July 2, 1976).

Khera, K.S., "Teratogenicity and Dominant Lethal Studies on Hexachlorobenzene in Rats," Food and Cosmetics Toxicology, 12: 471-477 (1974).

Lansade, M., Sur l'efficacité et l'emploi des Polychlorobenzènes dans le traitement de la carie du blé, Parasitica 5: 1-4 (1949).

Mackay, D. and A.W. Wolkoff, "Rate of Evaporation of Low-Solubility Contaminants from Water Bodies to Atmosphere," Environmental Science and Technology, 7: 611-614 (1973).

Mes, J., D.S. Campbell, R.N. Robinson and D.J.A. Davies, "Polychlorinated Biphenyl and Organochlorine Pesticide Residues in Adipose Tissue of Canadians," Bulletin of Environmental Contamination and Toxicology, 17: 196-203 (1977).

Mumma, C.E. and E.W. Lawless, Survey of Industrial Processing Data. Task 1. Hexachlorobenzene and Hexachlorobutadiene Pollution from Chlorocarbon Processing, EPA, PB-243 641 (1975).

National Academy of Sciences, Assessing Potential Ocean Pollutants, National Research Council, Washington, D.C., p. 188-208 (1975).

Neely, W.B., D.R. Branson and G.E. Blau, "Partition Coefficient to Measure Bioconcentration Potential of Organic Chemicals in Fish," Environmental Science and Technology, 8: 1113-1115 (1974).

Newton, K.G. and N.C. Greene, "Organochlorine Pesticide Residue Levels in Human Milk-Victoria, Australia-1970," Pesticides Monitoring Journal, 6: 4-8 (1972).

Organisation for Economic Cooperation and Development, "Preliminary Enquiry into Hexachlorobenzene, Paris, NR/ENV/75.18(Rev.) (July 30, 1975).

Schoettger, R.A., Annual Progress Report: 1972, Fish-Pesticide Research Lab., Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior, Columbia, Missouri, 57 pp. (1972).

Siyali, D.S., "Hexachlorobenzene and Other Organochloride Pesticides in Human Blood," The Medical Journal of Australia, 2: 1063-1066 (1972).

Vos, J.G., H.A. Breeman and H. Benschop, "The Occurrence of the Fungicide Hexachlorobenzene in Wild Birds and Its Toxicological Importance - A Preliminary Communication," Meded. Rijksfac. Landbouwwetensch. Gent. 33: 1263-69 (1968).

Vos, J.G, H.L. Van Der Maas, A. Musch and E. Ram, "Toxicity of Hexachlorobenzene in Japanese Quail and Special Reference to Porphyria, Liver Damage, Reproduction and Tissue Residues," Tox. Appl. Pharmacol. 18: 944-57, (1971).

Vos, J.G., P.F. Botterweg, J.J.T.W.A. Strik and J.H. Koeman, "Experimental Studies with HCB in Birds, " TNO-nieuws 27: 599-603 (1972).

Watts, R.M., HCB Residues in Eggs and Body Fat of Poultry Receiving HCB-Treated Wheat, Rpt. to Australian Pesticides Sub-Committee by N.S.W. Department of Agriculture (June 1968).

Yersin, H., A. Chomette, G. Baumann and J. Lhoste, "(Hexachlorobenzene, A Synthetic Organic Product Utilized in the Control of Wheat Bunt)," Compt. Rend. Acad. Agric. France 31: 24, (Abst. in Rev. Appl. Myc. 26: 150. 1947) (1945).

Zitko, V., "Polychlorinated Biphenyls and Organochlorine Pesticides in Some Freshwater and Marine Fishes," Bull. Environ. Contam. Toxicol. 6: 464-70 (1971).

# SOURCES OF HEXACHLOROBENZENE IN CANADA

## REPORT TO THE DOE/NH&W ENVIRONMENTAL CONTAMINANTS COMMITTEE

M. Gilbertson
Contaminants Control Branch
Environmental Impact Control Directorate
Environmental Protection Service
Ottawa, Canada

August 31, 1979

## 3.1 Introduction

At the 14th Meeting of the DFE/NH&W Environmental Contaminants Committee held on March 15, 1977, the committee agreed that programs must be developed to determine the sources of HCB to the Canadian environment. The regional offices of the Environmental Protection Service initiated studies of HCB through the Regional Environmental Contaminants Committees. This report is a national overview of environmental sources of HCB compiled from the reports prepared by each Region.

Two previous reports, one by the Bureau of Chemical Hazards (Meek, 1978) and the other by the Contaminants Control Branch (Gilbertson, 1978), were prepared which reviewed the toxicological and environmental aspects of HCB. These reports showed that hexachlorobenzene is a persistent compound that is bioaccumulated in food chains and has become dispersed in the Canadian environment. HCB is a toxic compound that causes porphyria, liver enlargement, proliferation of the smooth endoplasmic reticulum and induction of hepatic microsomal enzymes. HCB was shown to be potentially teratogenic in mice and to be carcinogenic in hamsters.

Potential sources of production of HCB were identified based on the list of known and theoretical HCB-producing processes reviewed by Mumma and Lawless (1975). The use of graphite anodes in chlor-alkali and sodium chlorate plants was suspected as a source of HCB. The known chlor-alkali plants in Canada are listed in Table 3.1, and the sodium chlorate plants in Table 3.2. The production of certain organic chemicals can result in the production of HCB. A list of these organic chemicals and their production sites in Canada is found in Table 3.3. Each Region is reviewed separately.

The use of certain pesticides such as Dacthal was one of the sources for environmental contamination with HCB. The production of Dacthal resulted in the formation of HCB and pastures treated with this compound resulted in contamination of livestock. In addition to looking at possible sources of HCB from industrial sites two regional offices analysed selected pest control products for their content of HCB. The results of these analyses are reviewed.

To check consistency of analytical quality between the analytical laboratories, two check samples were sent to laboratories participating in the HCB survey. The results of these analyses are also reviewed (see Appendix).

TABLE 3.1 CHLOR-ALKALI PLANTS IN CANADA-1979

| | |
|---|---|
| **Diaphragm Process** | |
| Extant: | |
| Canadian Occidental Petroleum Ltd. | N. Vancouver, British Columbia |
| Canadian Occidental Petroleum Ltd. | Nanaimo, British Columbia |
| Dow Chemical Company | Fort Saskatchewan, Alberta |
| Prince Albert Pulp Co. (membrane cell) | Saskatoon, Saskatchewan |
| Dow Chemical Company<br>Block 40<br>Block 130 | Sarnia, Ontario |
| Great Lakes Forest Products Ltd.<br>(membrane cell) | Dryden, Ontario |
| CIL | Becancour, Quebec |
| Defunct: | |
| Cominco | Trail, British Columbia |
| Two Hills Chemical Company | Two Hills, Alberta |
| Canadian Occidental Petroleum Ltd. | Brandon, Manitoba |
| Ontario People's Salt and Soda Co. | Kincardine, Ontario |
| Canadian Electro-Chemical Co. Ltd. | Sault Ste. Marie, Ontario |
| Canadian Salt Co. | Windsor, Ontario |
| Riordan Co. Ltd. | Merritton, Ontario<br>(St. Catharines) |
| Canadian International Paper | Temiskaming, Ontario |
| Domtar Chemical Ltd. | Cornwall, Ontario |
| Eddy Forest Products Ltd. | Espanola, Ontario |
| **Mercury Cell** | |
| Extant: | |
| FMC | Squamish, British Columbia |
| CIL Cornwall | Cornwall, Ontario |
| Stanchem | Beauharnois, Quebec |
| CIL Dalhousie | Dalhousie, New Brunswick |
| Canso | Abercrombie Point, Nova Scotia |

TABLE 3.1 CHLOR-ALKALI PLANTS IN CANADA-1979 (cont'd)

| | |
|---|---|
| Defunct: | |
| Prince Albert Pulp Co. (converted to diaphragm process) | Saskatoon, Saskatchewan |
| Dow Chemical I & III | Sarnia, Ontario |
| Great Lakes Forest Products Ltd. (converted to diaphragm process) | Dryden, Ontario |
| American Can of Canada Ltd. | Marathon Ontario |
| CIL | Hamilton, Ontario |
| Dow Chemical | Thunder Bay, Ontario |
| CIL Shawinigan | Shawinigan, Quebec |
| Alcan | Arvida, Quebec |
| Domtar | Lebel-sur-Quevillon, Quebec |
| Shawinigan Chemicals | Shawinigan, Quebec |

TABLE 3.2 SODIUM CHLORATE PLANTS IN CANADA-1979

| | |
|---|---|
| Extant: | |
| B.C. Chemical Ltd. | Prince George, British Columbia |
| ERCO Industries Ltd. | Vancouver, British Columbia |
| Canadian Occidental Petroleum Ltd. | Squamish, British Columbia |
| Canadian Occidental Petroleum Ltd. | Brandon, Manitoba |
| Huron Chemicals Ltd. | Marathon, Ontario |
| ERCO Industries Ltd. | Thunder Bay, Ontario |
| Dryden Chemicals Ltd. | Dryden, Ontario |
| Stanchem | Beauharnois, Quebec |
| ERCO Industries Ltd. | Buckingham, Quebec |
| QueNord Chemicals Ltd. | Magog, Quebec |
| Canso Chemicals Ltd. | Abercrombie Point, Nova Scotia |
| Defunct: | |
| Domtar | Lebel-sur-Quevillon, Quebec |
| Tidal Chemicals Ltd. | St. John, New Brunswick |

TABLE 3.3 ORGANIC CHEMICALS AND SITES OF POSSIBLE PRODUCTION OF HCB IN CANADA-1979

| | |
|---|---|
| Perchloroethylene | |
| Dow Chemical Co. | Sarnia, Ontario |
| CIL | Shawinigan, Quebec |
| Venchem (closed) | Shawinigan, Quebec |
| Trichloroethylene | |
| Dow Chemical Co. | Sarnia, Ontario |
| CIL | Shawinigan, Quebec |
| Venchem (closed) | Shawinigan, Quebec |
| Carbon tetrachloride | |
| Dow Chemical Co. | Sarnia, Ontario |
| Cornwall Chemical Ltd. | Cornwall, Ontario |
| CIL (no longer produced at this site) | Shawinigan, Quebec |
| Vinyl chloride | |
| Dow Chemical Co. (opening) | Fort Saskatchewan, Alberta |
| Dow Chemical Co. | Sarnia, Ontario |
| Gulf Oil (closed) | Varennes, Quebec |
| Pentachlorophenol | |
| Dow Chemical Co. (closed) | Fort Saskatchewan, Alberta |
| Uniroyal | Clover Bar, Alberta |
| Maleic hydrazide | |
| Uniroyal | Elmira, Ontario |

## 3.2 Pacific Region (British Columbia and Yukon)

There are three chlor-alkali and three sodium chlorate plants in the Pacific Region and these plants have remained in operation to the present time. The first survey of the possible HCB-producing plants was undertaken in the fall of 1974. Further studies

were undertaken in the fall of 1977 and in the fall of 1978; a summary report was submitted in May 1979.

**3.2.1 Chlor-alkali Plants.** Canadian Occidental Petroleum Ltd. operates two chlor-alkali plants, one in North Vancouver and a second in Nanaimo, B.C. FMC operates a chlor-alkali plant in Squamish. Cominco operated a plant at Trail but this plant was shut down in 1968 and was not included in the survey.

**Canadian Occidental Petroleum Ltd., North Vancouver**

First operated in 1957, this plant uses diaphragm cells and has a capacity of 400 tonnes of chlorine/day. At the time of the first survey in 1974, this plant was using graphite anodes in the cells and producing about 810 $m^3$/yr of chlorinated hydrocarbon sludge. This was stored in barrels and buried on plant property. In 1975, the cells were converted to dimensionally stable anodes (DSA).

The survey in September 1977 indicated that the plant effluent contained less than 5 ppt HCB. In the sludge disposal landfill site, the sample from the top 15 cm contained 95 ppb and the sample from between 15 and 46 cm contained 320 ppb. A third sample from the surface to 46 cm had undetectable HCB. A soil sample from outside the landfill area also had no detectable HCB, indicating that the compound was not leaching out of the landfill site.

**Canadian Occidental Petroleum Ltd., Nanaimo**

This plant came on line in 1964. It uses diaphragm cells with a capacity of 90 tonnes/day. This plant was not included in the first HCB survey in 1974. In the survey undertaken in the fall of 1977, this plant was converting the anodes in the chlor-alkali cells from graphite to DSA. This conversion was completed by 1979.

In the September 1977 survey, a grab sample of the plant effluent contained trace levels of HCB (<5 ppt). A composite of four sediment samples from various locations in a drainage ditch contained HCB at a concentration of 10.8 ppm. This drainage ditch served the plant area and discharged to the Northumberland Channel. A soil sample from landfilled solid waste contained 0.108 ppm HCB. A sample from the reboiler tank within the plant contained 1 270 ppm HCB. The brine mixture contained 0.017 ppm HCB.

In the second survey, undertaken in October 1978, a 4 hour composite effluent sample from the outfall contained 6 ppt HCB which was equivalent to an annual loading

0.05 kg/yr. Two grab samples from the drainage ditch contained 3 and 10 ppt HCB respectively. One of four soil samples from the drainage ditch contained 11 ppm HCB, two others contained about 1 ppm and the fourth contained about 0.1 ppm. A sample from the reboiler tank contained 350 ppm HCB.

Sediments and biota from Northumberland Channel were collected and analyzed on two occasions. Shoreline sediment (composite of 5 samples) taken 400 m from the plant contained 2.0 ppb HCB, while a similar composite sample collected 800 m from the plant contained no detectable HCB. Small crabs and barnacles collected at the 400 m sampling site contained 25.7 and 2.3 ppb HCB respectively. Similar samples collected one year later contained 7.0 ppb (crabs) and 2.0 ppb (barnacles) HCB, while sediments contained 7.0 ppb HCB. Composite samples of oysters, small crabs, and mussels collected 1.2 km from the plant contained no detectable HCB.

**FMC, Squamish**

This mercury cell plant came on line in 1965. The current chlorine production capacity is 180 tonnes/day.

During the 1974 survey the original graphite anodes were being replaced by electrodes made of titanium alloy. This replacement process was completed by 1975.

In the September 1977 survey, two grab samples from the inlet and outlet of the effluent pond contained 50 ppt and 110 ppt HCB respectively. Two grab samples from the point of discharge to the sea contained 40 ppt and 19 ppt. Sediment samples were collected from various locations. A sample from the inlet to the effluent pond contained 19 ppm HCB, from the outlet of the pond 5.6 ppm was detected and 250 ppb was found in a sediment sample near the pond discharge to the sea. Two sampling sites at the high tide line near the plant contained less than 1 ppb. A soil sample from the sludge disposal area on the plant property contained 5 ppb HCB.

In the August 1978 survey the mean concentration of eight individual water samples of the effluent taken at 0.5 hour intervals during one day was 35 ppt. This indicated an annual discharge of 0.45 kg HCB/yr. A composite sample had 14 ppt HCB and indicated an annual discharge of 0.18 kg/yr. A sediment sample from near the pond discharge to the sea contained 870 ppb and 5 ppb HCB was found in two sediment samples from locations at the low tide line.

Mussels and crustaceans collected approximately 200 m from the final outfall did not contain HCB.

During a routine maintenance inspection of the chlorine mist eliminator, FMC plant personnel discovered that the fiberglass core in the unit was coated with a white crusty solid. Analysis of this material at an analytical laboratory demonstrated that this deposit was 99.99% HCB. The FMC technical superintendent theorized that the HCB formation was due to the reaction of the graphite anodes with chlorine in the cells, and that the deposit had accumulated over a 9-year period prior to the plant changing over to the titanium-type anodes.

In order to recover the HCB it was necessary to slurry the solid in concentrated sulphuric acid. The slurry was then pumped into 45 I.G. steel drums, sealed, and labelled in preparation for transport to the United States. A total of 19 drums were shipped to an Oregon hazardous waste landfill operated by Chem-Nuclear Systems Inc. Eleven drums were two-thirds full of the $H_2SO_4$ - HCB slurry, four drums contained some unslurried HCB, and the remaining four drums contained the contaminated fiberglass packing material from the mist eliminator.

**3.2.2 Sodium Chlorate Plants.** Canadian Occidental Petroleum Ltd. bought out the Squamish Chemical sodium chlorate plant at Squamish between the 1974 survey and the survey in the fall of 1978. ERCO Industries operates a plant in North Vancouver and B.C. Chemical operates a plant in Prince George.

**Canadian Occidental Petroleum Ltd. Squamish (formerly Squamish Chemical)**

This plant was first operated in 1973 and has a current capacity of 14 000 tonnes/year of sodium chlorate. The electrodes are made of platinum.

Sludge from the plant was landfilled on the property. Results of analysis of samples from the landfill site and of the sludge did not show any detectable HCB.

**ERCO Industries, North Vancouver**

This plant was first operated in 1957 and has a current capacity of 160 tonnes/day. In the 1974 survey, the electrodes were reported to be made of graphite and the sludge was disposed of in the North Vancouver Municipal Landfill.

At the North Vancouver Municipal Landfill, water and sediments from storm sewer discharges and seepages contained no HCB above the level of detection and indicated that HCB disposed in the landfill was not leaching from the site.

This plant was surveyed in October 1977. Samples of water and sediment from the mud wash tank contained 130 ppb and 290 ppb HCB respectively. Samples from the

effluent to the lagoon contained 5 ppt HCB and from the lagoon to Burrard Inlet contained 29 ppt HCB. An effluent sample of discharge to the East Sewer Outlet contained 5 ppt HCB. Sediment from the lagoon contained 35 ppb HCB; however, a sample from the lagoon discharge to Burrard Inlet contained only 1 ppb. A sample from close to the East Sewer Outlet has 28 ppb.

**B.C. Chemical, Prince George**

This plant was on line in 1967 and was reported in the 1974 survey to use graphite anodes. No subsequent survey was undertaken.

**3.2.3 Other Industries.** A contract was let for sampling and analysis of sediments, fish and water as part of a general survey of chlorophenol contamination associated with the wood preservation industry. The consultants also reported levels of tetra-, penta- and hexachlorobenzene. HCB was found at the following plants: - Seaboard (Burrard Inlet), Crown Zellerbach (Fraser River), Canadian White Pine (Fraser River), Empire Mills (Squamish), British Columbia Forest Products (Victoria) and Somass and Alberni Pacific (Port Alberni).

**Seaboard, Burrard Inlet**

This export terminal is situated in North Vancouver on Burrard Inlet. There is a pentachlorophenol dip treatment plant associated with the terminal. Trace amounts (0.5 ppb) of hexachlorobenzene were detected in sediment samples. A sample of seven pooled livers of the Staghorn sculpin (Gymnocanthus tricuspis) contained 15 ppb HCB.

**Crown Zellerbach, Coquitlam**

This mill is situated on the Fraser River and has a pentachlorophenol spray and dip-treatment facility. HCB was not detected in the sediment or water samples but 8 ppb was found in the pooled liver sample of seven Prickly sculpins (Cottus asper) taken from this location.

**Canadian White Pine, Burnaby**

This wood mill has a pentachlorophenol spray plant and is located beside the Fraser River. Three of the five sediment samples from this location contained mean HCB levels over 1 ppb.

**Empire Mills, Squamish**

A sample of four pooled livers of Staghorn sculpins contained 54 ppb hexachlorobenzene. This sample was taken from a location close to this mill which has a pentachloropenol dip-treatment facility.

**British Columbia Forest Products, Victoria**

This mill has a spray and on-line-dip-facility. Four of five sediment samples had detectable levels of hexachlorobenzene. A pooled sample of three Staghorn sculpin livers taken from this location had 5.2 ppb HCB.

**Somass and Alberni Pacific, Port Alberni**

These two mills located at the northern end of the Alberni Inlet have pentachlorophenol spray treatment plants. Sediments from near the Somass plant had up to 31 ppb HCB. Two sediment samples from near the Alberni Pacific plant had a trace amount (0.5 ppb) of HCB.

Composite surface water samples from the two plants near effluent outfalls had 12 ppt HCB and composite effluent samples had 78 ppt HCB.

## 3.3 Northwest Region (Alberta, Saskatchewan, Manitoba and the Northwest Territories).

There are several industrial facilities in this region that may produce HCB as a waste product. There are two functioning diaphragm chlor-alkali plants - one in Alberta and one in Saskatchewan. The latter was converted from the original mercury cell process. There are two other plants, one in Alberta and the other in Manitoba that have closed. There is a functioning sodium chlorate facility associated with the closed chlor-alkali plant in Manitoba. In addition in Alberta there are two pentachlorophenol plants (one closed) and one vinyl chloride plant that is about to open. In 1978, the EPS Regional Office undertook a telephone enquiry to investigate HCB in this region.

**3.3.1 Chlor-alkali Plants.** One of the two functioning diaphragm chlor-alkali plants is at Fort Saskatchewan, Alberta, and is operated by the Dow Chemical Company; the other is at Saskatoon, Saskatchewan, and is operated by the Prince Albert Pulp Co. The Two Hills Chemical Company at Two Hills, Alberta, had a small capacity diaphragm process plant that closed in about 1972. Hooker Chemical Division shut down the diaphragm cell at Brandon, Manitoba.

**Dow Chemical Company, Fort Saskatchewan, Alberta**

Built in 1968, this plant utilizes a diaphragm cell process, and has a current capacity of 750 tonnes/day. No information was obtained on this plant during the 1978 enquiry.

**Prince Albert Pulp Co., Saskatoon**

This plant came on line in 1964 and was originally a mercury cell operation with a capacity of 70 tonnes/day. This facility closed in 1978 when a new diaphragm process was completed. The old facility had graphite anodes.

Solids produced from the purification of brine were sent to the salt cavities. Wastewater from the plant which contained mercury solids and mercury in solution were sent to a dump. The solids were recovered through a purification process; prior to the mid-1970s the mercury-containing wastewaters were sent to a deep well. In the later years most of the mercury-containing wastewaters were recycled. No information was available on the handling of solid/liquid wastes resulting from the purification process or on the amount of HCB produced by the plant.

**Two Hills Chemical Company, Two Hills, Alberta**

This diaphragm cell operated until about 1969. It was a small capacity plant (3 tonnes/day) and had graphite anodes. When in operation the muddy residues from the reaction vessels were deposited directly into an on-site landfill. No information was available regarding the handling of wastes from the chlorine purification process nor on the levels in the soil in the former landfill site.

**Canadian Occidental Petroleum Ltd., Brandon, Manitoba**

This plant operated from 1968 to 1978. The diaphragm cell chlor-alkali facility used graphite anodes and had a capacity of 37 tonnes/day. The process produced about 170 kg of residues per day which was disposed of by:

a) direct discharge to the process sewer and settling in the effluent settling basin;
b) periodic mechanical removal of the residue from the settling basin to the brine sludge pits located on the plant's property (undertaken in 1970, 1975, and 1977); and
c) periodic cleaning of the sewer drains in the chlorine cell room and subsequent disposal of residue in the City of Brandon municipal dump.

**3.3.2 Sodium Chlorate Plants.** There is one sodium chlorate production facility in the Northwest Region and this is operated by the Canadian Occidental Petroleum Ltd. at Brandon, Manitoba.

**Canadian Occidental Petroleum Ltd., Brandon, Manitoba**

This facility is associated with the chlor-alkali facility and both came on line in 1968. The plant has a capacity of about 35 tonnes/day and uses graphite anodes. If HCB is produced or released during the electrolysis process, it will be contained in the muddy residues in the bottom of the reaction cell. This muddy sludge is cleared out once a month and discharged into a settling basin. The solids are allowed to settle before the fluids are drawn off and discharged into a nearby river. Every five or six years the settling basin is drained and dredged. The dredged material is deposited in the on-site brine sludge pits.

**3.3.3 Other Industries.** The Dow Chemical Company operated a pentachlorophenol plant at Fort Saskatchewan, Alberta, until 1975. The second plant is operated by Uniroyal at Clover Bar, Alberta. The capacity of the Uniroyal plant is 1 800 tonnes/yr. No further information is available on these two plants.

In late 1979 Dow Chemical Company will open a vinyl chloride monomer plant in Fort Saskatchewan with a planned annual capacity of 320 000 tonnes.

**3.4 Ontario Region**

There are two functioning diaphragm chlor-alkali plants in Ontario one of which was converted from the mercury process. In addition, there are records of seven diaphragm plants that operated in Ontario since the turn of the century. There is one functioning mercury chlor-alkali plant and five others that were closed or converted. Ontario also has three sodium chlorate plants.

Perchloroethylene, trichloroethylene, carbon tetrachloride and vinyl chloride are manufactured at one organic chemicals plant and carbon tetrachloride is also produced at a second location. Maleic hydrazide is also produced at one location within the province.

### 3.4.1 Chlor-alkali Plants.

**Diaphragm Cell Process**

The Dow Chemical Company has a diaphragm cell chlor-alkali production complex at Sarnia. Great Lakes Forest Products Ltd. (formerly Dryden Chemical Company) produces chlorine at Dryden by the diaphragm (membrane) process in a new cell room built on the site of the original mercury cell plant. The seven defunct plants are: - the Ontario People's Salt and Soda Company at Kincardine; the Canadian Electro-Chemical Co. Ltd. at Sault-Ste-Marie; the Canadian Salt Co. at Windsor; Riordon Co. Ltd. at Merritton (St. Catharines); Canadian International Paper at Temiskaming; Domtar Fine Paper Ltd. at Cornwall and Eddy Forest Products Ltd. at Espanola.

**Mercury Cell Process**

The CIL Cornwall plant produces chlorine by the mercury cell process. The five plants that have closed are: - the Dow Chemical Company at Sarnia (2 plants); the American Can Co. at Marathon; the CIL Hamilton plant and Dow Chemical Co. at Thunder Bay.

**Dow Chemical Company, Sarnia**

The chlorine production facilities at this plant have undergone considerable change. The original plant (Dow Chemical I) was built as a mercury chlor-alkali plant in 1948. It used graphite anodes and continued in production until January 1973. The second plant (Dow Chemical II) was built as a diaphragm process in 1969 and had carbon anodes. This plant became known as Block 40. The third chlor-alkali facility (Dow Chemical III) was a mercury process using graphite anodes. This plant opened in 1970 but closed in 1973. Dow Chemical I and III were converted to the diaphragm process in 1972 and became known as Block 130. The capacity of Block 130 is about 400 tonnes/day and the capacity of Block 40 is about 300 tonnes/day.

A 1972 report by Rick Abbott, formerly of the Ontario Water Resources Commission, to the Advisory Committee on Pollution Control noted that effluent analyses provided by Dow Chemical Co. gave an indication of the levels of HCB encountered in wastewaters from chlorine and organochlorine production plants. The 1971 survey showed that at one outfall location between 0.018 and 0.136 kg of HCB was discharged/day. The higher figure indicated an annual discharge of about 45 kg/yr.

A letter, dated September 16, 1976, from Dr. D.M. Young, Manager of Environmental Affairs at Dow Chemical Co. at Sarnia, reported that for the first eight months of 1976 the average HCB loading was 0.27 kg/day. This is equivalent to over 90 kg/yr.

In 1973, the Ontario Ministry of Environment undertook a survey of the Dow Chemical Company dump site (Scott Road landfill) in Sarnia. Three surface water samples were collected from a drainage ditch and analysed for HCB. These samples contained 6, 7 and 8 ppb HCB.

Two 24-hour composite samples of surface water from a ditch in Sarnia township had 4 and 120 ppt HCB. A grab sample from the Scott Road landfill contained 24 ppt HCB.

**Great Lakes Forest Products Ltd.**

This plant was originally constructed as a mercury cell chlor-alkali facility in 1962. The process used carbon anodes to produce chlorine at about 35 tonnes/day. Diaphragm (membrane) cells with the same capacity were installed in 1975.

Data are not available on the past production of or disposal procedures for HCB-containing wastes.

**CIL Cornwall, Cornwall**

This mercury cell chlor-alkali plant was built in 1935. It has been modified over the years and has a present capacity of 160 tonnes/day. The plant used graphite anodes but now uses DSA. Samples of water were collected by the Ontario Ministry of Environment in June 1977 from the plant site. Neither of the samples had detectable HCB.

**Ontario People's Salt and Soda Company, Kincardine**

This diaphragm process chlor-alkali plant was built at Kincardine in the 1890s. Data are not available on the past production of or disposal procedures for HCB-containing wastes.

**Canadian Electro-Chemical Co. Ltd., Sault-Ste-Marie**

This diaphragm plant was on line in 1901. Data are not available on the past production of or disposal procedures for HCB-containing wastes.

**Canadian Salt Co., Windsor**

This diaphragm plant opened in 1911 and had a capacity of 100 tonnes/day. The plant continued in operation until 1954. Data are not available on the past production of or disposal procedures for HCB-containing wastes.

**Riordon Co. Ltd., Merritton, (St. Catharines)**

This diaphragm chlor-alkali plant opened in 1916 and closed about 1925. Data are not available on the capacity of the plant or on the past production of or disposal procedures for HCB-containing wastes.

**Canadian International Paper, Temiskaming**

This diaphragm plant operated from 1920 to 1967 and had a nominal capacity of 10 tonnes/day. Data are not available on the production of or disposal procedures for HCB-containing wastes.

**Domtar Fine Paper Ltd., Cornwall**

This diaphragm plant was built in 1922 and had a capacity of 10 tonnes/day. The chlor-alkali plant operated until 1971. In 1977 the paper plant was sampled and a concentration of 5 ppt HCB was detected in the clarifier effluent. Data are not available on the disposal procedures for HCB-containing wastes from the chlor-alkali plant.

**Eddy Forest Products Ltd., Espanola**

This diaphragm plant operated from 1947 to 1971 and produced about 20 tonnes of chlorine/day. Data are not available on the production of or disposal procedures for HCB-containing wastes.

**American Can of Canada Ltd., Marathon**

This mercury cell chlor-alkali plant was built in 1952 and had a capacity of 36 tonnes/day. The plant used graphite anodes and continued in operation until 1977. A membrane cell is being tested to evaluate its performance. Data are not available on the production of or disposal procedures for HCB-containing wastes.

Ten sediment samples were collected from the area around the town of Marathon (Beak, 1979a). The sample taken close to the town had 2 900 ppb HCB and indicated a source in the proximity of Marathon. An offshore sample had over 400 ppb HCB. Two sample sites to the south of the town had levels over 100 ppt indicating that

the contaminant may be transported in this direction. It is uncertain from the data what the background level might be; however, one sample contained 0.4 ppb.

**Dow Chemical Company, Thunder Bay**

This mercury chlor-alkali plant was opened in 1966 and had a capacity of 88 tonnes/day. The plant used graphite anodes and continued in operation until 1973. No data are available on the production of or disposal procedures for HCB-containing wastes.

Ten sediment samples were collected in Thunder Bay (Beak, 1979a). A plot of the distribution of the concentration of HCB indicated that there was a source of HCB leaking into Thunder Bay, probably located in or close to the town. The sample closest to the town had 575 ppb HCB and two samples taken further north and further south of the town had levels over 100 ppb. The background levels in the bay were about 0.5 ppb.

**CIL Hamilton, Hamilton**

Built in 1965, this mercury cell chlor-alkali plant had a capacity of 93 tonnes/day. The plant used graphite anodes and operated until 1973. No data are available on the production of or disposal procedures for HCB-containing wastes.

**3.4.2 Sodium Chlorate Plants.** There is an ERCO Industries Ltd. sodium chlorate plant at Thunder Bay. A second plant is operated by Huron Chemicals Ltd. for American Can of Canada Ltd. at Marathon. Great Lakes Forest Products Ltd. produces chlorate in Dryden.

**ERCO Industries Ltd., Thunder Bay**

This plant has been in operation since 1978 and the present capacity of the plant is about 13 500 tonnes/yr. The capacity is scheduled to increase to 31 500 tonnes/yr. It is uncertain whether graphite anodes are used. No data are available on the possible production of or disposal procedures for HCB-containing wastes.

**Huron Chemicals Ltd., Marathon**

This plant is operated by American Can of Canada Ltd. but is owned by Huron Chemicals Ltd. It came on line in 1952 and has a capacity of 900 tonnes/yr. It is uncertain whether graphite anodes are used. No data are available on the possible production of or disposal procedures for HCB-containing wastes.

**Great Lakes Forest Products Ltd., Dryden**

This plant came on line in 1962 and has a capacity of 4 000 tonnes/yr. Graphite anodes are used but no data are available on the possible production of or disposal procedures for HCB-containing wastes.

**3.4.3 Organic Chemicals Plants.** The Dow Chemical Company manufactures perchloroethylene, trichloroethylene, carbon tetrachloride and vinyl chloride at Sarnia. Carbon tetrachloride is also produced by Cornwall Chemicals Ltd. at Cornwall. Maleic hydrazide is manufactured by Uniroyal at Elmira.

**The Dow Chemical Company**

The information from this company has been reviewed above under the section on chlor-alkali plants.

**Cornwall Chemical Ltd., Cornwall**

This company is a subsidiary of CIL Cornwall. The effluent from the carbon tetrachloride plant was sampled by the Ontario Ministry of Environment in June 1977 and found to contain 7 ppt HCB. No flow data are available to estimate the total HCB loading from the plant. The plant was again sampled in 1977 as part of a PCB survey undertaken by the Environmental Protection Service of Environment Canada. No HCB was detected. Samples collected in 1979 contained between 2 and 86 ppt HCB.

**Uniroyal, Elmira**

This pesticide manufacturing plant was not surveyed in the present study.

**3.4.4 Other Industries.**

**Polysar, Sarnia**

Mean levels of HCB in 24-hour composite samples from service water and four effluents was 6 ppt (range from 2 ppt to 15 ppt) (Beak, 1979b).

**3.4.5 Other Information.** A series of ten samples were collected from Michipicoten Bay and most had levels about 1.5 ppb (Beak, 1979a). One sample, however, had 34 ppb and the possibility of a source in this area cannot be eliminated.

**3.5 Quebec Region**

In the Quebec Region there are two chlor-alkali plants in operation and four that have been closed. There are three sodium chlorate plants now operating; one closed

in 1978. One organic chemical plant makes perchloroethylene and trichloroethylene. Another perchloroethylene/trichloroethylene plant has closed. One vinyl chloride monomer plant was also located in the province.

In 1978 the EPS Quebec Region contracted a study with Sodexen Incorporated to prepare an inventory of HCB production and use. Later the same year and in 1979, the Regional Office undertook a survey of plants that were likely sources of HCB.

**3.5.1 Chlor-alkali Plants.** Canadian Industries Ltd. (CIL) operates a diaphragm chlor-alkali plant at Becancour. Stanchem operates a mercury cell chlor-alkali plant at Beauharnois. There are also four defunct mercury cell chlor-alkali plants in the province; CIL at Shawinigan, Alcan at Arvida, Domtar at Lebel-sur-Quevillon and Shawinigan Chemicals at Shawinigan.

**CIL, Becancour**

This diaphragm cell chlor-alkali plant went on stream in 1975. The process uses DSA anodes and produces about 390 tonnes/day. Recently, CIL has doubled the capacity of the plant. The plant was not included in the survey because new devices were being installed.

**Stanchem, Beauharnois**

This mercury cell chlor-alkali plant was built in 1949 and originally used graphite anodes. In 1970 the plant was renovated and converted to DSA. The capacity is about 170 tonnes/day. This plant was not sampled because at the time of the survey it was being reconstructed after a fire. No data are available on the production of or disposal procedures for HCB-containing wastes.

**CIL, Shawinigan**

This mercury cell chlor-alkali plant went on line in 1936 and operated with graphite anodes. The plant closed in January 1979 and had a capacity of 100 tonnes/day.

An effluent sample from the chlor-alkali unit had a concentration of 10 ppt HCB and a flow rate of 820 L/min. A second effluent sample from the chlor-alkali unit had an HCB concentration of 280 ppt and a flow rate of $4.55 \times 10^6$ L/day. Samples of the muddy residue from the electrolytic cells contained HCB at a concentration of 11.8 ppm and 15.3 ppm HCB.

Air samples taken downwind of the CIL Shawinigan plant using the mobile TAGA system did not contain HCB at or above the limit of detection of 0.23 ng/$m^3$. No data are available on the disposal procedures for HCB-containing wastes.

**Alcan, Arvida**

This mercury cell chlor-alkali plant was built in 1947 to supply caustic soda for the production of aluminum. The mercury cells used graphite anodes and the plant had a capacity of about 80 tonnes/day. The chlor-alkali plant was closed down in 1977. This plant complex also fabricates graphite anodes for the production of aluminum and this process may involve the use of hexachlorobenzene.

A liquid effluent from the aliminum smelter had a concentration of 30 ppt and a flow of 45 x $10^6$ L/day; this was equivalent to a discharge of 785 grams of HCB/year. A sediment sample from the Mathias marsh was analysed in duplicate; one had 22 ppb and the other had 230 ppb HCB. Other sediment samples from streams close to the plant had mean values of 16 and 30 ppb HCB. Sludges from the plant are accumulated in a landfill site.

**Domtar, Lebel-sur-Quevillon**

This mercury cell chlor-alkali plant was built in 1961 and operated with graphite anodes. The plant had a capacity of about 60 tonnes/day. The plant ceased operation in May 1978.

No sampling or analysis was undertaken on this plant but HCB residues are known to have been landfilled on the plant site.

**Shawinigan Chemicals, Shawinigan**

Shawinigan Chemicals operated a mercury cell chlor-alkali plant until 1968. The mercury cells used graphite anodes. No further information has been collected on waste disposal or environmental levels near the plant.

**3.5.2 Sodium Chlorate Plants.** Three sodium chlorate plants are operating in Quebec. Stanchem operates a sodium chlorate plant at Beauharnois and ERCO Industries Ltd. produces chlorate at Buckingham. A new sodium chlorate plant operated by QueNord Chemicals Ltd. at Magog is now in production. In addition, sodium chlorate was produced by Domtar at Lebel-sur-Quevillon but the company closed the chlorine/chlorate facility in 1978.

**Stanchem, Beauharnois**

This plant has already been reviewed in the above section on chlor-alkali plants.

**ERCO Industries Ltd., Buckingham**

This sodium chlorate plant was built in 1897 and has a capacity of about 200 tonnes/day. The electrolytic cells have graphite anodes. The HCB-containing residues from this plant are concentrated and put in a clay-lined pit.

A liquid effluent sample from the process stream and from the cooling system had a concentration of 10 ppt HCB and a flow rate of $17 \times 10^3$ L/min. This is equivalent to an annual loading of about 140 g/yr HCB. A sediment sample was analysed in duplicate and had a mean HCB content of 825 ppb.

**Domtar, Lebel-sur-Quevillon**

This company has already been reviewed in the above section on chlor-alkali plants.

**QueNord Chemicals Ltd., Magog**

This company is producing about 25 000 tonnes/yr of sodium chlorate. The cells are using DSA.

**3.5.3 Organic Chemicals Plants.** The province of Quebec also has several organic chemical industries that may be associated with the production of HCB. Perchloroethylene and trichloroethylene are produced by CIL and were produced by Venchem at Shawinigan. Gulf Oil had a vinyl chloride monomer plant at Varennes.

**CIL, Shawinigan**

Despite the closure of the chlor-alkali plant in January 1979, the chlorinated solvents plant has continued to operate. This plant produces perchloroethylene and trichloroethylene. The results of the HCB survey of this plant have been reviewed above under the section on chlorine production.

**Venchem, Shawinigan**

The Venchem plant was opened in 1975 for the production of trichloroethylene and perchloroethylene using excess chlorine from the Alcan Arvida chlor-alkali plant.

The plant was designed for a capacity of 7 000 tonnes of perchloroethylene and 13 500 tonnes of trichloroethylene/year, but was closed in 1977. No samples were taken at this plant. Wastes from the facility were incinerated at the Tricil incinerator at Mercier.

**Gulf Oil Canada Ltd., Varennes**

This plant opened in January, 1967 for the production of vinyl chloride monomer, and closed in September, 1975. The HCB-containing wastes were accumulated during this period in a sealed pit for subsequent transport for incineration at Garden City in the United States. Samples were not taken at this plant.

**3.5.4 Other Industries.** The Regional Office sampled other industries as part of a general chlorobenzene survey. Hexachlorobenzene was found at the following plants:-

**Wood Preserving**

The Domtar wood preserving plant at Delson had an effuent with 140 ppt HCB and a flow rate of $455 \times 10^3$ L/day. This was equivalent to 36 grams of HCB/year.

A sediment sample from the process stream ditch had 690 ppb HCB.

The Goodfellow Lumber Sales Ltd. plant at St-André-Est had 50 ppt HCB in the final process effluent. Two sediment samples from the canal receiving the process effluent had HCB levels of 32 and 68 ppb. A sediment sample collected 60 metres from the discharge of the canal into the North River had 173 ppb HCB.

**Pyrotechnics**

Two streams that receive effluent from the CIL explosives plant at McMasterville had 20 ppt and 140 ppt HCB. This was equivalent to a total annual HCB loading of about 180 g/yr.

**Textiles**

The effluent from the Celanese Canada Ltd. plant at Drummondville had 10 ppt HCB and a mean flow rate of $14.7 \times 10^6$ L/day, equivalent to an annual HCB loading of 83 g/yr. Two sediment samples from the effluent pond had 115 ppb and 310 ppb HCB.

Sediment from the aeration pond at the Dominion Textiles Ltd. plant at Magog had 120 ppt HCB. Water from the aeration pond had 1970 ppt and water from the settling pond had 20 ppt. The flow rate through the plant is $19 \times 10^6$ L/day; thus the amount of HCB passing through the aeration pond was equivalent to 21 kg/yr.

Water from the settling pond of the Dominion Textiles Ltd. plant at Beauharnois had a concentration of 100 ppt HCB and a flow rate of $0.91 \times 10^6$ L/day, this was equivalent to an annual discharge of 52 g/yr HCB.

**Paints**

The effluent from the paint and lacquer manufacturing plant of the Sherwin-Williams Company in Montreal had a concentration of 110 ppt HCB and a flow rate of 270 L/min. The effluent from the alkyde paints process had 120 ppt and a flow rate of 160 L/min. These indicate a total annual discharge of less than 41 grams of HCB.

**Chemicals for Textiles and Pulp and Paper**

A sample of water from the cooling system and from floor-washing at the Record Chemicals Inc. plant at Montreal had a mean concentration of 3 100 ppt HCB. The total flow through the plant was 6 800 L/day and indicated an annual HCB loading of 16 g/yr.

A sample of water from the Bayer Inc. warehouse at Point-Claire had a concentration of 80 ppt HCB. The plant had an effluent flow rate of 90 L/min and this indicated an annual loading of about 6 g/yr.

Similarly a sample from the Clough Industries Co. Ltd. plant at St. Jean d'Iberville had a concentration of 170 ppt HCB and a flow rate of $162 \times 10^6$ L/yr indicating an annual discharge of about 42 g/yr.

**Glues and Adhesives**

The cooling water at the Canadian Adhesives Ltd. plant in Montreal had a concentration of 210 ppt HCB and a flow rate of 14 000 L/day. This indicated an annual loading of less than 0.1 g/yr.

**Industrial and Domestic Soap**

Process water and floor-washing water from the Savon Majestic Ltd. plant in Montreal contained 3.0 ppb HCB and had a flow rate of $2.3 \times 10^6$ L/day. This was equivalent to an annual loading rate of 4 kg/yr HCB.

**Pesticide Formulation**

A sample of sludge from the processing plant of Chipman Chemicals Ltd. at Buckingham contained 165 ppb HCB.

**Incineration of Industrial Wastes**

Samples of air, downwind of the Tricil, Ville Mercier incinerator, were analysed for HCB at three sampling sites but this compound was not detected at a limit of 0.23 $ng/m^3$.

Similarly, HCB was not detected in air samples downwind of the Des Carrières Incinerator in Montreal.

## 3.6 Atlantic Region (Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick)

In the Atlantic Region there are three plants that were identified as possible producers of HCB. A preliminary survey was undertaken on two of these plants between September and November 1977. This preliminary survey was not restricted to HCB but included all the chlorobenzenes. Samples were taken from other plants that might produce other chlorobenzenes. All the analyses were performed to look for all chlorobenzenes. A second survey was undertaken by contract in January and February 1979.

**3.6.1 Chlor-alkali Plants.** CIL Dalhousie operates a mercury cell chlor-alkali plant at Dalhousie, New Brunswick. The second chlor-alkali plant is operated by Canso Chemicals at Abercrombie Point, Nova Scotia.

**CIL Dalhousie, Dalhousie, New Brunswick**

This mercury cell chlor-alkali plant came on line in 1963 and has a capacity of about 80 tonnes/day. It originally had graphite anodes but now has DSA.

Samples of the final effluent from the settling pond had a concentration of 50 ppt HCB. Pentachlorobenzene was also detected at a concentration of 20 ppt.

**Canso Chemicals, Abercrombie Point, Nova Scotia**

This chlor-alkali plant came on stream in 1970 with a capacity of 70 tonnes/day. It originally had graphite anodes but changed to DSA in 1975.

Sampling was undertaken of the influent and effluent of the settling pond. The influent had 60 ppb HCB and 1 ppb of pentachlorobenzene. The effluent from the settling pond had 40 ppt HCB and 17 ppt pentachlorobenzene. The settling pond appears to have been effective in removing the chlorobenzenes from the final effluent. No estimate had been made of the quantity of these chlorobenzenes in, or discharged to, the settling pond.

It is uncertain whether chlorobenzenes are still being formed in the plant or whether their continued discharge is from past practices with the graphite anodes.

A marine sediment survey in 1979 showed that levels of HCB 60 m from the outfall were over 200 ppb but that levels declined to less than 100 ppb at a distance of 90 m. One sample at about 60 m from the outfall had over 100 ppb pentachlorobenzene. All other samples were below 50 ppb.

**3.6.2 Sodium Chlorate Plants.** Canso Chemicals at Abercrombie Point (reviewed above) also has a sodium chlorate facility within the same plant as the chlor-alkali facility. The effluents from the two facilities are processed and discharged together, therefore, this plant is not reviewed further. The second sodium chlorate plant, Tidal Chemical Ltd. at St. John, New Brunswick has closed.

**Tidal Chemical Ltd, St John, New Brunswick**

This plant came on stream in 1971 and has a capacity of 14 000 tonnes/yr. No survey was undertaken on this plant.

**3.6.3 Other Industries.** The regional office sampled other industries as part of the general chlorobenzene survey. Hexachlorobenzene was found at some of the plants.

The Laurentide Chemicals plant had an effluent from the latex wash with 1.1 ppb HCB. All chlorobenzenes were detected in the latex wash and this material is disposed of in the municipal landfill site.

The effluent from the blast furnace cooling water at the Sydney Steel Co. in Sydney, Nova Scotia contained 20 ppt HCB.

The Stellarton Coal Washing Plant at Stellarton, Nova Scotia, had an effluent with 70 ppt HCB.

The Fraser Companies' pulp and paper plant at Altholville, New Brunswick, had 20 ppt in the final effluent.

No estimates of the quantities discharged were made.

## 3.7 Pesticides

Several analyses have been performed on pest control products that are known to have contained HCB. These analyses were undertaken to ascertain whether these products were still likely to be sources of HCB to the environment. Several products that were analysed for HCB by the EPS Pacific Region are listed in Table 3.4.

Products that were analysed for HCB by the EPS Quebec Region are listed in Table 3.5.

TABLE 3.4 HCB IN PESTICIDES SAMPLED IN THE PACIFIC REGION

| Product | Agent | HCB (ppm) |
|---|---|---|
| Atrazine | Laters Chemical | 0.55 |
| Atrazine | Green Valley Fertilizer | 0.25 |
| Dacthal (1973) | Van Waters & Rogers | 80 000 |
| Dacthal (1973) | Van Waters & Rogers | 56 000 |
| Dacthal (1976) | Green Valley Fertilizer | 84 000 |
| Dacthal (1976) | Green Valley Fertilizer | 90 000 |
| Pentachlorophenol | Green Valley Fertilizer | 10 |

TABLE 3.5 HCB IN PESTICIDES SAMPLED IN THE QUEBEC REGION (1978)

| Product | Agent | HCB (ppm) |
|---|---|---|
| Atrazine | Chipman Chemicals Ltd. | 4.2 |
| Dacthal | Diamond Shamrock Corp. | 1048 |
| Princep | Ciba-Geigy | 15.2 |
| Pentachlorophenol | Domtar Chemicals | 46.6 |
| Pentox | Osmose Wood Preserving Co. | 6.0 |
| Pentox | Osmose Wood Preserving Co. | 0 |
| Pentox | Osmose Wood Preserving Co. | 0.85 |
| Pentox | Osmose Wood Preserving Co. | 202.1 |
| Pentox | Osmose Wood Preserving Co. | 4.2 |
| Pentox | Osmose Wood Preserving Co. | 4.4 |
| Pentox | Osmose Wood Preserving Co. | 1.3 |

It is recommended that detailed studies should be undertaken of the Dow Chemical Company plant at Sarnia, Ontario; the CIL plant at Shawinigan, Quebec; and the Cornwall Chemicals Ltd. plant at Cornwall, Ontario.

A preliminary study should be undertaken at the Uniroyal pentachlorophenol plant at Clover Bar, Alberta, and of the maleic hydrazide plant at Elmira, Ontario.

**Wood Preserving Plants**

The use of pentachlorophenol for wood preservation in British Columbia has resulted in the contamination of sediments and fish with hexachlorobenzene. The source of the HCB is uncertain and further analytical work should be undertaken on the wood preservatives to determine the level of HCB.

**Other Industrial Plants**

The national survey included several samples from industries that are not traditionally associated with HCB contamination. The Dominion Textiles Ltd. plant at Magog appeared to discharge a significant quantity of HCB and should be investigated further to determine the source in the plant. Similarly the source of HCB in the Savon Majestic Ltd. soap plant in Montreal should be investigated.

**Pest Control Products**

Several pest control products contained HCB. Samples of Dacthal from the Pacific Region collected in 1973 and 1976 contained between 5 and 9% HCB. Some samples of pentachlorophenol and pentox contained ppm levels of HCB and one contained over 200 ppm. Similarly Atrazine contained HCB in the ppm range.

The Department of Agriculture should be requested to analyse pest control products that are likely to contain HCB to investigate the levels of HCB that are in current stocks. Particular attention should be given to the HCB content of pentachlorophenol and Dacthal.

## 3.8 Discussion and Recommendations

**Chlor-alkali Plants**

Though the data are incomplete, the survey indicates that chlor-alkali plants do produce small quantities of hexachlorobenzene if graphite anodes are or have been used. For instance, when the CIL Dalhousie plant in New Brunswick was sampled it still used graphite anodes and the effluent from the plant had 50 ppt HCB. The modification of the anodes to dimensionally stable anodes (DSA) does not necessarily result in the discharge of HCB being eliminated. The Canadian Occidental Petroleum Ltd. chlor-alkali plants at North Vancouver and Nanaimo, B.C., the FMC plant at Squamish, B.C., and the Canso plant at Abercrombie Point, Nova Scotia, all changed to DSA but still had HCB in the effluent. This finding may indicate that the process streams still contain traces of

HCB and that a long time is required for the HCB to be removed from the contaminated plants. The total amount of HCB discharged by the chlor-alkali industry appears to be negligible and appears to be less than a pound per year per plant. These findings are in contrast to the evidence presented in Mumma and Lawless (1975) which indicated that the HCB content of the waste would be between 2 and 5%.

**Sodium Chlorate Plants**

The situation appears to be similar for sodium chlorate facilities. HCB is discharged from the ERCO Industries Ltd. plants in Vancouver, B.C., and Buckingham, Quebec, where graphite anodes have been used. The Canadian Occidental Petroleum Ltd. plant at Squamish, B.C., has used DSA since the plant began production in 1973. No HCB was found in the effluent. Where data are available the quantity and concentrations appear to be very small.

**Organic Chemicals Plants**

The Dow Chemical Company at Sarnia, Ontario, is a complex of chlorine-producing and using facilities. About 100 kg of HCB was discharged per year and this was the largest verifiable source in the survey. The survey of the Dow plant did not separate the relative contribution to the total HCB loading from the various processes including the chlor-alkali plant, the trichloroethylene, perchloroethylene, carbon tetrachloride plant and the vinyl chloride monomer plant.

In the U.S., about 90 percent of the estimated 8 million pounds of HCB produced annually is a by-product at 10 perchloroethylene, 5 trichloroethylene and 11 carbon tetrachloride manufacturing plants. Most of the remaining production is a by-product at more than 70 other sites producing chlorine and certain pesticides. Clearly, the present study has not given sufficient attention to the chlorinated-solvent production plants including the Dow Chemical Company at Sarnia, Ontario, CIL at Shawinigan, Quebec, the former Venchem plant at Shawinigan, Quebec, and the Cornwall Chemical Ltd. plant at Cornwall, Ontario.

No data have been produced on the possible HCB production from the pentachlorophenol or maleic hydrazide plants.

**REFERENCES**

Beak, Study of Toxic Substances in the Great Lakes: Trace Organic Analyses, report to Process Research Division, CCIW Burlington (July 1979a).

Beak, Review of Environmental Levels and Point Source Releases of Hexachlorobenzene in Ontario, report to Ontario Region of the Environmental Protection Service, Toronto (July 1979b).

Gilbertson, M., Hexachlorobenzene: Background Document on the Situation in Canada, report prepared by Contaminants Control Branch (DFE) for the DFE/NH&W Environmental Contaminants Committee (April 1, 1978).

Mumma, C.E. and E.W. Lawless, Survey of Industrial Processing Data. Task 1. Hexachlorobenzene and Hexachlorobutadiene Pollution from Chlorocarbon Processing, EPA, PB-243 641 (1975).

Meek, B., Hexachlorobenzene: Background Document on the Situation in Canada with Respect to Human Health, report prepared by the Bureau of Chemical Hazards (NH&W) for the DFE/NH&W Environmental Contaminants Committee (April 25, 1978).

# APPENDIX

## ANALYSIS OF CROSS CHECK

## SAMPLES FOR HCB

## APPENDIX

## ANALYSIS OF CROSS CHECK SAMPLES FOR HCB

The survey of sources of hexachlorobenzene to the environment was undertaken by the five regional offices of the Environmental Protection Service. Samples of effluent, sludge and sediments close to outfall pipes or to lagoons were analysed either by contract or in the EPS regional laboratories. A check-sample program was initiated to ensure that analytical results were comparable between laboratories. The staff of the Toxic Chemicals Division of the Canadian Wildlife Service participated in the national check-sample program run by the Federal Interdepartmental Committee on Pesticides. As a part of this program, two chicken eggs were spiked with organochlorine compounds, homogenized and frozen in aliquots. These aliquots were initially sent to seven laboratories. Subsequently four sets of aliquots were sent to EPS offices in the Pacific, Northwest, Quebec and Atlantic Regions. The contractor for the EPS office in Ontario had already participated in the initial check-sample program.

The results are shown in Table A.1. Three of the four regions undertook the analyses. The contractor for the EPS Pacific Region only found 34% in one sample and 51% in the second sample. The contractor for the EPS Quebec region found 117% in one sample and 120% in the second sample. The moisture content of the samples was 73%; however, the Quebec contractor only found 40.4% moisture content. The Atlantic regional laboratory submitted their results after the draft of this report was sent to the regional offices. The laboratory found 78% in the first sample and 80% in the second sample.

TABLE A.1 COMPARATIVE ANALYSES FOR HCB CONTAMINATION

| Laboratory | Moisture Content | Check-sample No.1 | Check-sample No.2 |
|---|---|---|---|
| Canadian Wildlife Service | 73% | 0.23 | 0.092 |
| Pacific | not determined | 0.079 | 0.047 |
| Northwest | - | - | - |
| Quebec | 40.4% | 0.27 | 0.11 |
| Altantic | 74% | 0.18 | 0.074* |

* Results reported after draft report was sent to the regional offices